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Astronomical Discoveries Due to Photography.

By IRENE E. TOYE WARNER.

MANY and varied have been the uses of the camera in the science of astronomy, for the photographic films are far more sensitive than the human eye, cannot become fatigued, and permanently register all they "see," and thus very faint objects such as certain telescopic comets, nebulæ, minor planets, etc., would never have been discovered without their aid. In a short untechnical sketch, like the following, we can but glance at a few of the more important facts connected with this rapidly growing branch of astronomical work.

The Sun.—It has played a very noticeable part in the study of the great luminary of our system, being first really systematically applied in the solar eclipse of July 18, 1860. In that year the line of totality traversed Spain, and Warren de la Rue and Secchi dispatched photoheliographic instruments to that country and set them up in two different places—Rivabellosa, in the upper Ebro valley, and Desierto de las Palmas, about 250 miles to the south-east, overlooking the Mediterranean. Both observers were most successful in obtaining good photographs of the wonderful flame-like prominences which issued from the solar orb in all directions; several appeared on the plates which were not visible in the ordinary telescope. Thus the proof so eagerly sought was at last obtained, that these red protuberances were, indeed, appendages of the sun and did not belong to our satellite as many people had imagined.

Splendid photographs were secured of the eclipse of December 12, 1871, and these showed for the first time the "remarkable *branching* forms" of the gaseous material ejected from the corona of the sun. In the eclipse of May 17, 1882, Dr. Schuster measured and photographed about thirty new bright lines, and these were the first really successful pictures of the spectrum of the corona as seen in a slit-spectroscope. Those of the corona itself were the best ever taken, and a bright comet near the sun added greatly to the beauty of the photos. It was from these that Dr. Huggins derived an idea of a means of taking photos of the corona without the aid of an eclipse, by the exclusion of all other kinds of light except that with which he hoped to operate. This was done by using chloride of silver as his sensitive material, "that substance being [says Agnes Clerke] inert to all other but those precise rays in which the corona has the advantage." At the present time no eclipse expedition is considered complete without full photographic appliances. The instrument used for solar photography is called the photo-heliograph. On a clear day pictures of the sun 8 inches in diameter can be obtained with an exposure of about $\frac{1}{500}$th of a second. It is also used for the registration of the numerous spots, etc., visible so frequently on the sun's disc.

The Planets.—Photographs of the planets are very disappointing, less detail being shown than on good drawings. This is particularly noticeable in those of the largest planet of the solar system—Jupiter, whose disc shows much delicate detail when viewed by an experienced observer with a good telescope. No doubt in the future we may hope for greater success in this interesting branch of astronomy, and the time may come when we shall have a really accurate series of pictures of the most important planets.

Photograph of Trails of Stars at the North Pole.
Telescope stationary for five hours (Rotation of the Earth).
By Prof. E. E. Barnard. 6-inch Portrait Lens. Lick Observatory.

The Stars.—Photography will always play a very important part in determining the amount of the proper motion of the stars, and will be invaluable in forming correct maps of the heavens. The Henry Brothers, of Paris, deserve very high praise for the valuable pioneer work they did in stellar photography. Astronomers throughout the world have joined in an effort to get plates of the whole sky; these are intended to form a general "reference library" by which changes in stellar magnitude or position can be discovered by comparing the photos now taken with any that shall be obtained in the future. The detection of new stars and long-period variables will form an important branch of this work. Perhaps the most interesting of these variable star discoveries (says Professor Barnard) were found in the photos of globular clusters taken by Professor Bailey. Many of these small stars varied rapidly and

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regularly in their light. They are so abundant that "as many as a hundred of them have been found in a space in the sky that would be covered by a pin's head held at the distance of distinct vision."

The greatest number of these variables are in M. 3, Omega Centauri, M. 5, and a few others. Professor Pickering, from ten years' photographic observation, has found that, strangely enough, no variation in light (with, perhaps, two slight exceptions) is perceptible in the great cluster in Hercules. Over five hundred variables have been discovered photographically by the Harvard observers. The shortest period of variation known being that of a star in the Omega Centauri cluster, which goes through its changes in 7 hours.

The discovery of *new stars* is likely to become more frequent now than it was in earlier times. It is interesting to know that the Nova, in Auriga, first noticed by Dr. Anderson on February 1, 1892, was found, on examining plates taken by Professor Pickering, to have been really visible as far back as December 10 of the previous year. It had escaped notice for two months! Dr. Max Wolf's photos of that region on December 8 showed no trace of the star, so that its appearance must have been extremely sudden some time between the 8th and 10th. A careful watch is now kept for these apparitions, and in this photography will play a useful part.

Spectro-photography has revealed a new class of binary star systems, in which the components are too close to have ever been seen visually. These binaries revolve in short periods, a few days, and, even in one case, in a few hours, and must, therefore, be very close to each other. One of the first of these spectroscopic binaries discovered by photography was Beta Aurigæ, which was detected through the doubling of its spectral lines on the photographic plates. The components of Algol (Beta Persei) have also been found to be composed of a luminous and a dark body, the latter of which partially eclipses the former at intervals of a little under three days.

Photos of stars were obtained as far back as 1850, and in 1857 G. P. Bond started measuring double stars by means of photography, beginning on Mizar, in Ursa Major. From a comparison of negatives taken by Dr. Gould in 1866 with Bessel's places for about fifty stars in the Pleiades we learn that their distance is so great that no change of position is noticeable in the twenty years. In the case of the sun and moon, instantaneous photographs can be taken, but for stellar work the camera has to be fixed to the telescope and slowly moved by mechanical means to follow the motion of the stars. Reflecting telescopes have hitherto given the best results as the rays of light of every colour falling on their mirrors are reflected at exactly the same angles.

By the employment of dry plates long exposures became possible, and Dr. Roberts frequently took "three-night photographs," and since every additional second procures images of stars too faint to be recorded instantaneously and also far beyond ordinary telescopic vision, we see how important this branch of the science is rapidly becoming. Stars down to the 16th magnitude are clearly shown on the photos, and in a space in the Milky Way, in Cygnus, where only 170 stars had been known by the old drawing method, about 5,000 were visible on a single Henry plate!

Nebulæ.—Very successful photos have been taken of the many nebulæ in the heavens, some of which are quite invisible to the eye even with the aid of the most powerful telescopes. In this branch of photography Professor E. E. Barnard, of the Yerkes Observatory, has done magnificent work. Near Rho Ophiuchi (see plate) is a wonderful region full of nebulosities that are too faint to be seen with the telescope, and would, therefore, never have been suspected had it not been for photography; near Gamma Cygni is a very faint and diffused nebula quite beyond the reach of the telescope, as is also another in Monoceros, and yet another in Orion. Although the Great Nebula in Andromeda has been known for about 2,000 years, yet its true shape was not revealed until 1885, when Roberts, with a 20-inch refractor, obtained some successful photos showing, says Professor Barnard, a "beautiful symmetrical mass of nebulous matter surrounded with several more or less concentric rings, claimed by some astronomers to be a presentation of the nebular hypothesis of La Place in full operation." The faint spiral nebula surrounding Maia, in the Pleiades, was first noticed on a

Photograph of Swift's Comet.
April 7, 1892.
By Prof. E. E. Barnard. 6-inch Portrait Lens. Lick Observatory.

negative taken in 1885 and afterwards confirmed by direct observation in 1886 by the Pulkowa 30-inch equatorial. It is visible in much smaller telescopes now that it is known to exist, as is often the case in astronomical work. A photo taken by Professor Roberts in 1886 of the same group revealed faint nebulous clouds stretching in all directions from the stars Alcyone, Electra, Merope, and Maia.

Comets.—To Professor Barnard belongs the honour of having made the first photographic discovery of a comet, on October 12, 1892. Fortunately it is periodic and returns to the sun every six years. The camera has revealed much of the wonderful structure of comets' tails and the rapid and remarkable changes they so frequently undergo. We have just had a good example of this in Comet Morehouse, which has shown a great variety of shapes and changes of brilliancy, and has been altogether, perhaps, the most interesting yet photographed. In some of the plates it shows a strong likeness to Swift's comet in April, 1892 (see photo). Without the camera both comets would probably have

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North.

Nebulous Region of Rho Ophiuchi.

Photographed with the 10-inch Bruce Telescope, Yerkes Observatory, in 1905, April 5. Exposure 4h 30m. By Prof. E. E. Barnard. The star at the South of photo. is Antares, to the right of which is M4. Above the latter is Sigma Scorpii. Rho Ophiuchi is in the centre (North) of the plate. Dark "lanes" run from the nebula out eastwards.

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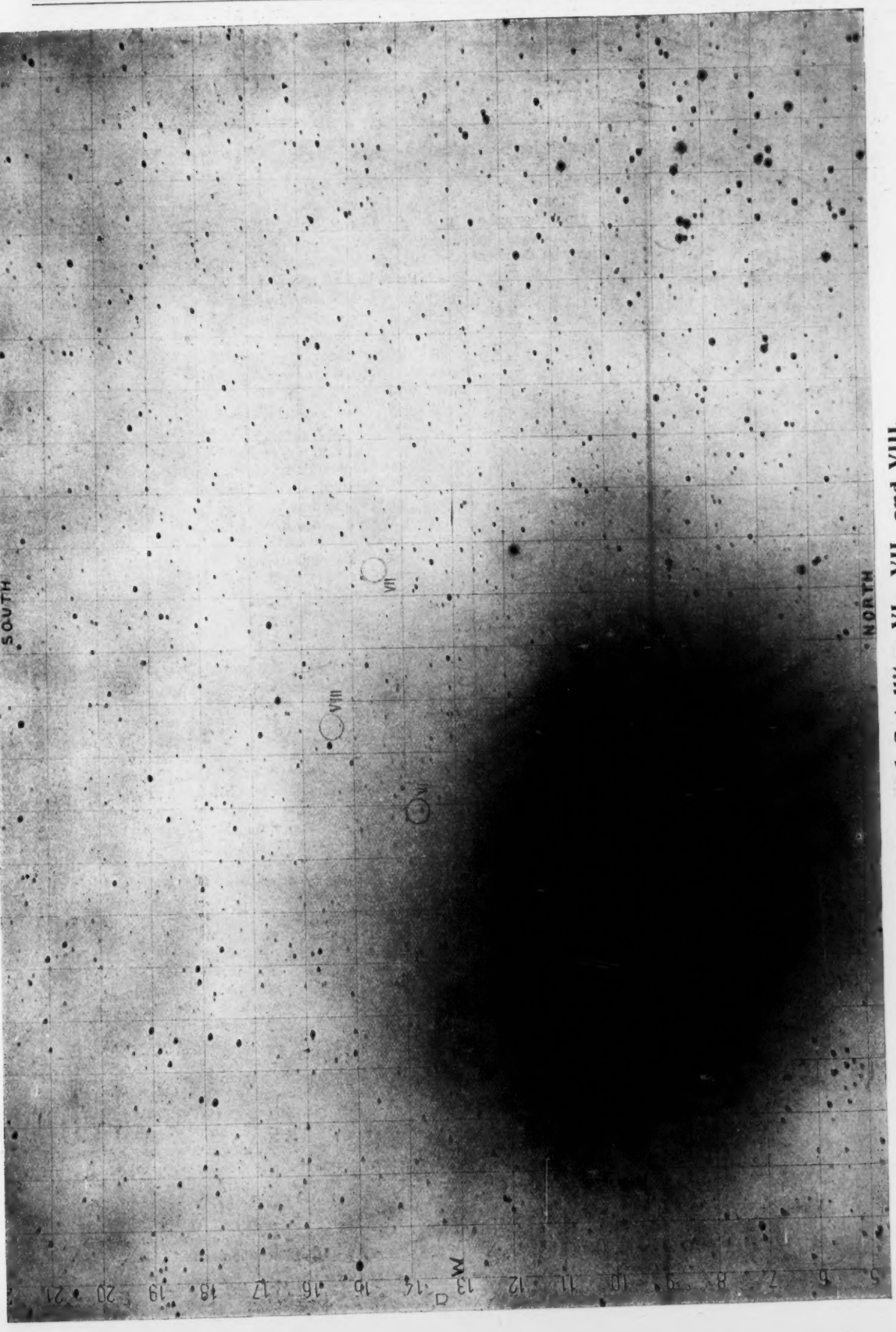

Jupiter and Satellites VI., VII. and VIII.

Enlarged twice from negative taken with 30-inch Reflector (focal length 11 ft. 5 in.) in 1908, February 28. Exposure 80 minutes. The telescope was made to follow Jupiter, thus causing the stars to trail. The satellites will be found as round dots at the centres of the small circles marked VI., VII and VIII. The image of Jupiter appears reversed in the middle of the glare. Scale: One reseau interval = 5'.

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passed as quite ordinary, as so much detail would have been lost. Halley's comet, the most celebrated of all our celestial visitors, will almost certainly be found photographically long before it becomes visible to the eye. Many comets have been thus found since the first was discovered in 1892, but most of them are extremely faint and so have not excited popular notice.

Satellites.—The planet Saturn has had two new satellites added to his kingdom, the first being discovered in August, 1898, at Harvard, by Professor W. H. Pickering, on the photos taken at that observatory. For some time nothing more was learnt of this object until in July, 1904, several further photographs were obtained, and Professor Barnard succeeded in detecting the new satellite visually with the Yerkes refractor. Phœbe, as it is named, moves at the great distance from Saturn of eight millions of miles in a retrograde direction, that is, like the hands of a watch, its period is 546.5 days, and its diameter about 200 miles. It is, therefore, the largest planetary body discovered since 1851, when Lassell found the inner satellites of Uranus, and, being very faint, it would probably have escaped detection but for the camera. The tenth satellite, Themis, also discovered on Professor Pickering's photos, has a revolution period of about 21 days, and is a little less distant than the eighth, Hyperion.

The planet Jupiter has also had three new satellites discovered by the aid of photography. In 1904 Perrine saw Satellite VI., and the following year Satellite VII. was added to the list of photographic captures. The discovery of the eighth satellite last year (1908) caused a good deal of excitement. To Mr. P. Melotte, of Greenwich Observatory, belongs this honour. It needed keen sight and careful study to notice the tiny speck, representing the new body, on the photograph of Jupiter's 6th and 7th satellites taken on February 28 with the 30-inch reflector, the space of sky photographed being about 2° square (see plate). It was then not far from Satellite VI., and on comparing previous photos, the "moving object" was traced back as far as January 27; this new moon appeared a little brighter than Satellite VII. It was photographed by Professor Wolf, of Heidelberg, on March 3; also from the Lick Observatory, in America, as well as from Greenwich during March and April. Its motion is retrograde, like that of Phœbe, at a distance from the planet about three times as great as that of Satellite VII., and the revolution period is thought to be about four years.

Photography has been applied with great success in the discovery of planetoids—or, as they are usually called, Minor Planets—ever since Professor Max Wolf detected the first in this manner in 1892. The old method of charting the stars and noting the planetoid by its motion was very tedious work, and at the present time all this kind of observation is done photographically. The telescope is usually driven by clockwork and keeps the stars steadily in view, and the minor planet, should there be one in the region under survey, leaves a short trail on the plate.

For permission to reproduce Mr. Melotte's photograph of Jupiter's VIIIth satellite, I am greatly indebted to the kindness of the Astronomer Royal. The satellite is visible as a small dot in the middle of a circle, and Jupiter may just be glimpsed in the centre of the flare on the left of the plate. The photo of the great nebula of Rho Ophiuchi is one of the finest examples of "photographic nebulosities," *i.e.*, nebulosities that are too faint to be seen with the most powerful telescopes, so would never have been discovered but for the camera. Professor E. E Barnard, of the Yerkes Observatory, U.S.A., has most kindly given me this beautiful example of the marvels of celestial photography, also the smaller illustrations in this article.

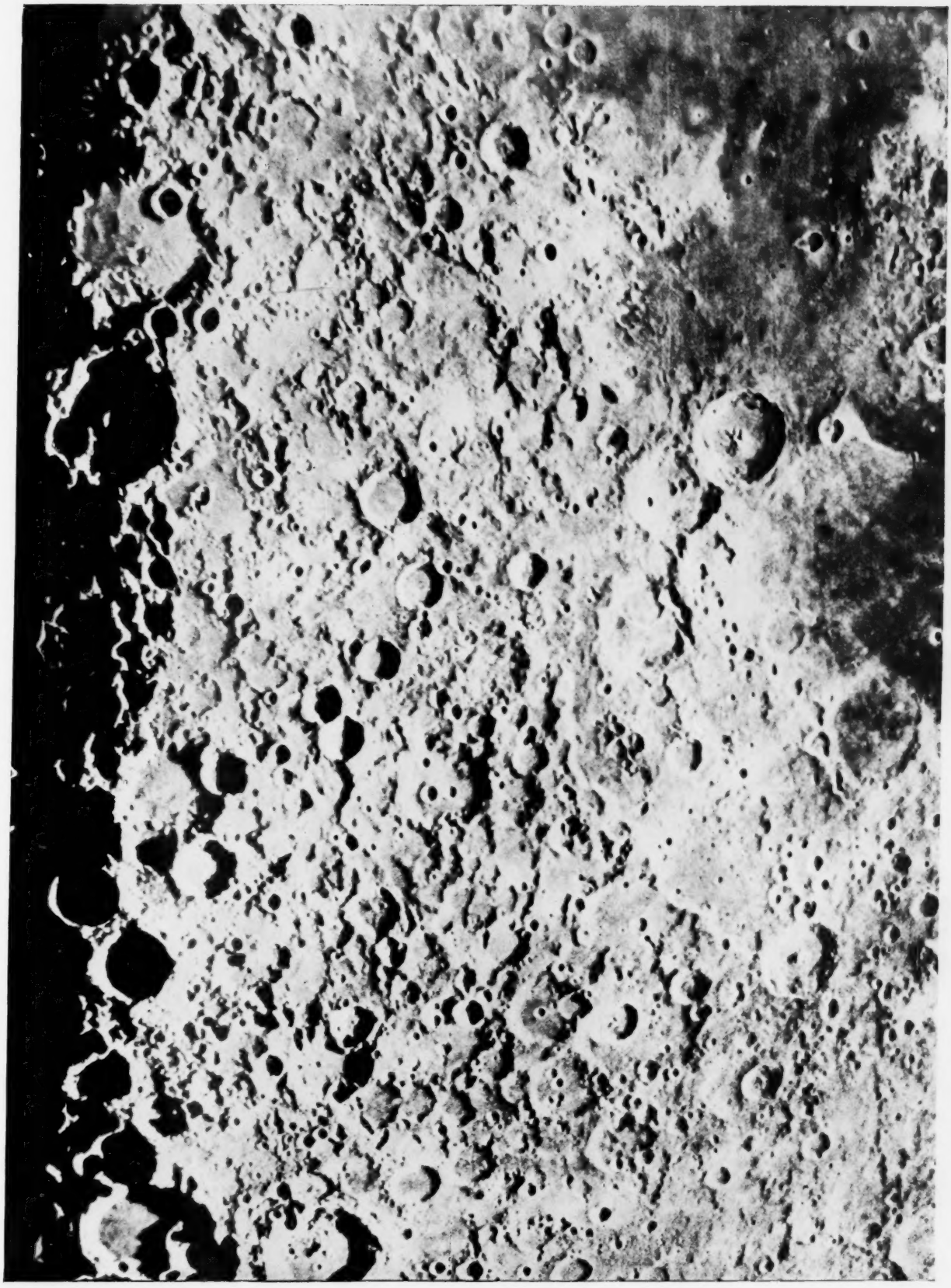
[According to the *latest* calculations the period of Jupiter's VIIIth satellite is thought to be about two years.]

An Atlas of the Moon.

WE publish with the present number of "KNOWLEDGE" the third of a series of large-sized plates of the moon. These plates are made from the magnificent photographs of the moon which are the work of MM. Lœwy and Puiseux, of the Paris Observatory, from which they have been taken by special permission. We also desire to acknowledge our indebtedness to the Royal Astronomical Society, who have been kind enough to place their photographs, together with every facility for reproducing them, at our disposal. The series of plates will number twelve in all, and, when completed, they will form an atlas of the moon.

Almost the first attempt in lunar photography was made by J. W. Draper, of New York, in 1840, and since then many thousands of views have appeared. In 1850 Bond, Whipple, and Black secured some Daguerreotypes of the moon with a 15-inch refractor. These showed a good amount of detail, and were exhibited at the Great Exhibition of 1851 in London, where a prize medal was obtained. Great improvements in method were made in 1851 by Legay, Fry, and Archer, from which date until 1876 the wet plate process was almost exclusively employed. Useful work was done in lunar photography by Secchi in Rome, MM. Bersch and Arnauld in France, and Dancer in England. The latter obtaining negatives which would bear microscopic observation with a 3-inch objective. Among the most successful pictures of all were those of De la Rue, who took photos with a 13-inch speculum of 10 feet focal length, the diameter of the image being about 1.1 inches. In 1857-1859 he procured still better results until 1879, when his work in this direction was discontinued.

In 1863 Lewis Rutherfurd undertook the construction of the first photographic object-glass ever made, and better results were obtained in 1865 than had been possible before. Professor Burnham, in 1888, with the great Lick telescope took some beautiful negatives comprising one entire lunation, and in 1896 the Lick Observatory began the publication of their photographic atlas of the moon. The Paris Observatory has devoted much time to the same lunar work. Ritchey has carried lunar photography to a very high pitch of excellence, his pictures showing more detail than has ever been previously recorded in that way. Although the camera has done much valuable work in fixing detail, which is difficult in telescopes up to 7 or 8 inches aperture, yet it has not succeeded in superseding the visual method in those above this diameter in recording really fine markings. Much useful work yet remains to be done in this direction, as by comparing views of the lunar landscape taken at widely separated periods we shall be able to find out if any physical alteration has occurred. Ordinary *drawings*, however accurate they may be, frequently vary in slight details—slight, that is, as we judge, but, in reality, perhaps erroneous to the extent of many miles. On the other hand, the greatest possible exactness is procurable by the photographic method, and any change on the moon's surface would be recognised by careful comparisons.



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The Moon.

A lower portion of the first quarter.

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The Walrus.

By W. P. PYCRAFT, F.L.S., F.Z.S., M.B.O.U., &c.

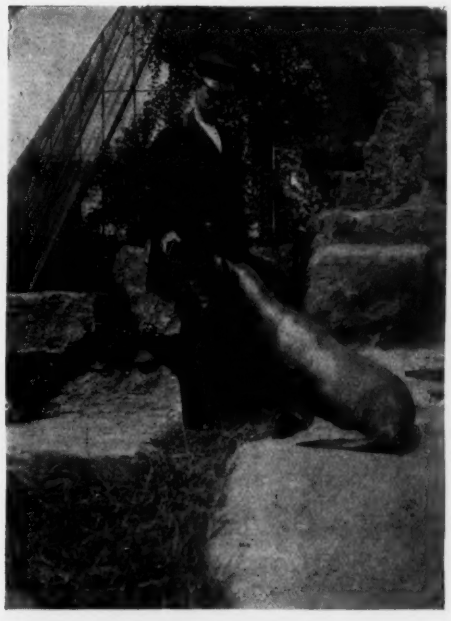
DURING the last few weeks of 1908, and the greater part of January of this present year of grace, dwellers in London interested in natural history had the rare chance of seeing a live walrus—though minus the carpenter, for these seem now inseparable! To be quite correct, there were a pair of walruses, but one soon met with an untimely end, while the survivor succumbed to London fog. Both were very young animals, the largest not exceeding six feet in length, but the opportunity of seeing such a beast in the flesh, even though immature, was one not lightly to be missed.

During the days of their captivity they were housed in a corner of the sea-lions' pond, where they were carefully screened from their more powerful neighbours, yet not so as to prevent a close comparison of the bodily peculiarities of the two species. Allied by ties of blood, and possessing, as might be supposed, certain characters in common, the walrus has gone farthest in the direction of specialisation, and it is proposed here to dwell in some detail on the trend which this departure has taken, and the significance of the differences between the two animals—sea-lion and sea-horse, as they are called.

First of all attention must be drawn to the more salient features of the first-named. This animal, then, structurally, if not by descent, occupies an intermediate position between the true seals on the one hand, and the walrus on the other, inasmuch as it is less specialised than either, though it has obviously undergone profound structural transformations in adaptation to its peculiar mode of life. Thus, while in the seals the hind limbs have so degenerated as to have lost the power of being turned forwards, and so contributing to the support of the body when on land, in the sea-lions, or fur-seals, or sea-bears, as they are indifferently called, these limbs still perform an ambulatory function, and this is true also of the walrus, though in both animals the use of the hind legs has become extremely restricted. When swimming these limbs serve as a rudder, and hence the tail has degenerated till all that is now left is a mere stump.

In the general conformation of the trunk the sea-lion and sea-horse have most things in common, but when the two creatures are closely compared there will be found many striking points of difference. In the first place the sea-lion is "clipper built," is made for speed, as is shown by the long neck, long flippers, and body, and the small head. All indicate a framework built for the pursuit of a swiftly-moving prey. As might be supposed, they are fish-eaters. Crabs, however, are commonly eaten, at any rate by some species, and the hard shells thereof, after having yielded up all the nutriment they contained, are regurgitated in form of a bolus, after the fashion which obtains among many birds. That fish must form the staple diet of these creatures might be inferred from the large mouth and formidable array of pointed teeth. As touching the eyes, it may be remarked that these are large, and necessarily so, while the ears have become reduced to mere finger-like vestiges. Finally, the body is clothed with an abundant crop of long hair, backed up by the peculiarly soft, velvet-like under-fur, which has, unfortunately, a high commercial value. We say unfortunately advisedly, for the traffic in "seal-skins" has been accompanied by nameless barbarities, and the most ruthless slaughter.

But to return to the walrus. Though near akin to the sea-lion, and resembling it in the general conformation of the body, this creature differs, as we have remarked, from its relative in some very striking particulars. In the first place it is a far larger and more bulky beast, bigger in the barrel and shorter in the neck; while in the matter of clothing it has little to boast, for, except when very young, the skin is but sparsely covered, at best, with short hair, and in very old animals hair may be said to be conspicuous by its absence. Warmth is maintained by an enormously thick layer of blubber. The flippers are, relatively, much shorter than in the sea-lion, and the eye also is much smaller. It is, in short, obviously a more sluggish animal, and this indicates that it must feed upon creatures which are not capable of quick movements. A glance at the teeth would confirm all the inferences drawn from the general bodily structure; yet these



Sea-lion, showing the position of the hind-limbs when on land. From a Photo. by Professor R. Beck.

are the most striking feature of the whole animal. And this because what answer to the upper canines of the sea-lion are here produced into a pair of great tusks, used, it is generally believed, for digging purposes, and to anchor the body to projecting rocks at need. These tusks, which are of ivory, were formerly much in demand, and still fetch a fair price. All the remaining teeth, and these are few, are reduced to mere tubercles which barely cut the gum. A dentition such as this gives encouragement to no suspicion of fish-eating! But, on the other hand, it is supposed to confirm the statements that have been made to the effect that this animal lives entirely upon shell-fish. It is universally believed, indeed, that the huge tusks are used for tearing luscious molluscs from their comfortable, if muddy, beds, to be crushed to pulp by the miniature millstones within the mouth. This may be so, but the young walruses at the Zoo, to which we have referred, seem to indicate a very different mode of feeding. The muzzle of the walrus, it should be remarked, is sharply and obliquely truncated, giving to the head a quite peculiar appearance, and the effect is heightened by the

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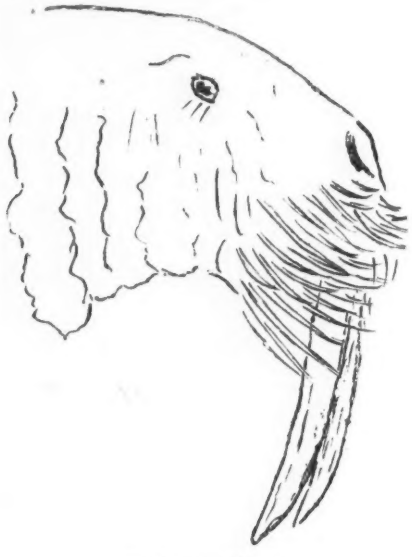
enormous lips beset with translucent bristles, which, in the matter of length, would not disgrace the spiny armature of the hedgehog, or even the fretful porcupine! The part these play in feeding is not apparent, but it would seem that the food is obtained at, or near, the surface of the water, and that it is of a character which requires neither crushing nor mastication. This is the inference, at any rate, that one must draw after watching the two captives in the London Zoo. When fat or fish roes were thrown to these animals they made no attempt to seize them after the fashion of their relatives the sea-lions, but momentarily pursing the great fleshy lips to form a kind of spout, the luscious morsel was swiftly drawn into the mouth by a quick indrawing of the breath, and was instantly swallowed without any attempt at mastication. It may well be, of course, that full-grown animals do employ their tusks as they are said to do, and do supplement their diet of slops with more solid shell-fish. But the table-manners of the two animals here referred to seem to throw doubt on the usually accepted theory.



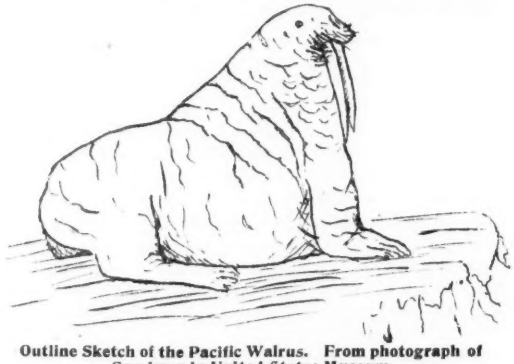
Head. (*After Murie.*)

To what are we to attribute the hairlessness of the walrus? The sea-lion, when it emerges from the water, has the appearance of an animated bronze statue, but the walrus has a hide wrinkled and gnarled like an oak tree, and almost as innocent of hair! This absence of fur is apparently due to the fact that it has been functionally replaced by a thick layer of blubber beneath the skin, as in the whales and porpoises. But seals and sea-lions also accumulate much fat. This, however, appears to be used rather as a reserve store of food, and in this these creatures resemble many land animals. Fat supplies so accumulated are liable to become exhausted, and hence render the retention of the hair necessary, but in the walrus and whales and their kind this absorption does not take place.

And now a word as to the size of the walruses. They were but a few months old and quite small. The males, which are much bigger than the females, attain a huge bulk. Tales are told, indeed, of walruses of over 16 feet long, but 11 or 12 feet would be much nearer the mark, while the maximum weight may be put, perhaps, at nearly 2½ tons. As touching the tusks, it may be remarked that specimens measuring as much as 31 inches, and weighing some 8 lbs. apiece, have been obtained, but nowadays big tuskers, as with elephants, are rare; tusks exceeding a weight of 4 lbs. seldom come into the market at the present day. In the females the tusks are always smaller.

That the walrus is degenerate as regards its teeth is shown by the fact that in the adult the molars have been completely lost, or, at most, are represented, in rare cases, by minute vestiges of one or two in the upper and one in the lower jaw. Of the premolars not more than two in the upper and three in the lower jaw are generally present, while the incisors are generally wanting; at most there is but one in front of each of the upper tusks. In the young animal, on the other hand, that is to say, in the milk dentition, no less than thirty teeth are present as against fourteen in the adult! He has long since become earless, and is on the way towards toothlessness, save, perhaps, for the tusks.

Reference has already been made to the fact that the limbs, and especially the fore-limbs, of the walrus are relatively inferior in size to those of the sea-lions, but it may further be remarked that the fore-limbs differ still further in that the palm of the hand is armed with a warty pad, apparently to aid in getting a better grip of the ice on which so much of its life is spent. As in the sea-lions, the nails are reduced to mere vestiges, and are quite functionless; this, indeed, must be so, since the tips of the fingers are produced beyond the nail to a relatively enormous extent, apparently for the



Outline Sketch of the Pacific Walrus. From photograph of Specimen in United States Museum.

sake of increasing the size of the flipper. As a consequence, the nail is reduced to the position of a mere horny scale embedded in skin, and serving only to mark the position of what was once the end of the finger! Though the hind-flippers serve, probably, mainly for steering purposes, it is possible that they may occasionally be used as organs of propulsion; at any rate, they perform this function in seals, though it would appear only in exceptional circumstances.

If on land, the walrus is one of the most helpless of creatures, in the water, at any rate, it is at ease. It is said, indeed, to sleep at sea, and during this period of repose floats bolt upright. This may well be true, for the peculiar shape of the nostrils, and their position on the surface of the sharply-truncated head, would render such a position more easy to maintain than would the horizontal plane assumed during the hours of activity.

Rare as the walrus has now become, it is to be hoped that the Zoological Society will yet have another chance of obtaining specimens. Time was when this strange beast was to be met with in vast herds, in suitable localities, throughout the northern hemisphere.

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Auroral Curtains.

In prehistoric times it extended as far south as these Islands, for remains have been dredged from the Dogger Bank, and have been obtained from the peat near Ely. Gradually, however, their numbers have been reduced till they are now on the verge of extinction. The story of the ruthless persecution to which these animals have, for centuries, been subjected may well be left for another occasion, for it does not make pleasant reading. Suffice it to say that between the years 1870-80 some 100,000 were slain in the Behring Sea alone!

Previous to the purchase of Alaska by the United States about 10,000 were slain annually by the Eskimos, but there was some justification for slaughter here, since these people depended upon this animal very largely for food, fuel, light, boats, dog-harness, and leather. To-day these inhabitants are themselves reduced to very slender numbers, for their main support has vanished.

The hunting of the walrus in the Atlantic began about the year 1600, and from that time till within the last few years the annual slaughter was appalling.

Auroral Curtains.

Sky Effects in the Antarctic.

In the album published by the Royal Society of photographs which were made in the Antarctic during the voyage of the "Discovery," there is a special supplement of drawings of auroral effects. These were drawn by Mr. Edward A. Wilson, and though the phenomena which they pourtray are essentially ephemeral, they impart a most instructive and interesting idea of the appearance and development of auroral streamers and arcs. An auroral glow, according to Mr. Wilson's description, is first perceptible over the outlines of the hills. This grows till it takes the frequent form of a bow or arch. The arch lifts and is followed by another and another till, after a succession of arches, their place is, in part, taken by vertical lines of light. These vertical lines often assume an appearance which is exactly like that of curtains in the sky. The folds of the curtains are continually moving and changing. Their appearance can hardly fail to call to mind the verses in the Psalms and in Isaiah: "O Lord, Thou art clothed with honour and with majesty . . . . who covereth Thyself with light as with a garment, who stretchest out the Heavens like a curtain"; and again: "It is He that stretcheth out the Heavens as a curtain, and spreadeth them out as a tent to dwell in." The lines which form the curtains very often rise eventually as if the folds were being drawn up into a star-like shape or corona—"coronal arch" is the name adopted. Mr. Wilson, in a description of these unique and beautiful drawings, says that the colour of the Antarctic auroral lights is mealy and straw coloured or a pale golden yellow. In the Northern hemisphere the most frequently occurring colours are red with green behind the red.

Relationships Between the Spectra of Allied Elements.

By W. Marshall Watts, D.Sc.

Spectroscopic relationships between the elements forming a natural family are to be expected. The chemical nature of a molecule depends upon the same magnitudes—mass, and forces between atoms—on which possible vibrations depend. If elements are nearly related chemically, *i.e.*, form similar compounds, then probably their molecules are similarly built, and hence we may expect similarity in spectra. The most certain way of discovering such relationships would be to establish first of all the laws of relationship between the different lines of each element separately, and then by comparison of these laws we may hope to reach the desired result.

Lecoq de Boisbaudran, in 1859, called attention to the similarity in the spectra of the metals of the alkalies and alkaline earths; remarking that the spectrum of cæsium is like that of potassium shifted bodily towards the red. It seems highly probable that the red lines of cæsium 9528, 8950, of rubidium 7950, 7805, and of potassium 7699, 7666, correspond to the sodium yellow lines 5896, 5890; the vibrations associated with the heavier molecules being slower in some sort of proportion with the atomic weight.

Mascart, in 1859, called attention to the series of double lines in the spectrum of sodium, and the series of triplets in that of magnesium. Hartley, in 1882 remarked the similarity in the spectra of zinc and cadmium, if mapped upon the scale of inverse wave-lengths (or oscillation-frequencies), pointing out the correspondence between the series of triplets in the two metals. He also made the important observation that the differences in oscillation-frequency between the members of the triplets in any one spectrum were constant.

A most important advance was made by Balmer, in 1885, who showed that the oscillation-frequencies of the lines of the hydrogen spectrum, including both the well-known lines of the hydrogen vacuum-tube Hα 6563.0, Hβ 4861.5, Hγ 4340.7, Hδ 4101.9, and the continuation of the series revealed in stellar spectra by the splendid photographs of Sir William Huggins* could be calculated by the extremely simple formula

$$1/\lambda = 27418.75\ (1 - 4/m^2),$$

in which m is given successively the values 3, 4, 5, etc. As the value of m increases the lines must approach closer and closer together and end at the "convergence-frequency" 27418.75.

This series is represented in Fig. 1, which is a copy (by permission) of some of the photographs of stellar spectra in the "Atlas of Representative Stellar Spectra," by Sir William and Lady Huggins.

The extraordinary close agreement between calculated and observed values is most remarkable, and leaves no doubt that the vibrations represented by the different lines of the series are connected physically in some rhythmic manner.

The following are the calculated and observed values for the hydrogen spectrum:—

Wave-length.	m.	Oscillation Frequency in Vacuo. Observed.	Calculated.
C 6563.042	3	15232.7	15232.6
F 4861.49	4	20564.1	20564.1
γ 4340.66	5	23031.6	23031.7
δ 4101.89	6	24372.2	24372.3
ϵ 3970.25	7	25180.2	25180.5

* *Phil. Trans.*

Wave-length.	m.	Oscillation Frequency in Vacuo. Observed.	Calculated.
ζ 3889.15	8	25705.3	25705.1
η 3835.6	9	26064.2	26064.8
θ 3798.0	10	26322.3	26322.0
ι 3770.7	11	26512.8	26512.4
κ 3750.15	12	26658.1	26657.1
λ 3734.15	13	26772.3	26771.8
μ 3722.0	14	26859.7	26859.2
ν 3712.0	15	26932.1	26931.3
ξ 3703.99	16	26990.3	26990.3
ο 3697.22	17	27039.8	27039.3
π 3691.71	18	27080.1	27080.3
ρ 3687.05	19	27114.4	27114.9
σ 3682.93	20	27144.7	27144.9
τ 3679.48	21	27170.1	27170.1
υ 3676.43	22	27192.6	27192.2
φ 3673.81	23	27212.0	27211.4
χ 3671.53	24	27228.9	27228.3
ψ 3669.52	25	27243.8	27243.3
ω 3667.70	26	27257.3	27256.5
3666.15	27	27268.9	27268.3
3664.71	28	27279.6	27278.9
3663.40	29	27289.3	27288.3
3662.14	30	27298.7	27296.9
3661.16	31	27306.0	27304.6

Readers of "KNOWLEDGE" may like to be referred to a paper by the former editor, the late A. C. Ranyard, "On the Rhythmical Group of Hydrogen Lines Visible in Many Stellar Spectra," in the number for September, 1891; and to one on "The Spectrum of Helium," by E. Walter Maunder, in that for April, 1896.

The important advance made by the verification of Balmer's formula was followed in 1888 by the announcement of Professors Kayser and Runge that they had discovered a general law of spectra. Their papers are contained in the *Abhandlungen* of the Academy of Science of Berlin, 1888 to 1893. They find that the lines of many spectra fall into series, represented (in each series) by a formula which is an extension of Balmer's, viz.: $\frac{1}{\lambda} = A - Bm^{-2} - Cm^{-4}$ where A, B and C are constants, and m has the values 3, 4, 5, etc., in succession.

Only in the case of elements of comparatively low atomic weight do these formulæ account for *all* the lines of the spectrum; with elements of high atomic weight either there are many lines which cannot as yet be brought under any law, or the lines are so numerous and *apparently* distributed at random, that no law whatever can be detected. An account of the results of Kayser and Runge's examination of the spectra of helium, lithium, and sodium is given in Maunder's paper previously referred to. Briefly, as regards the spectra of the metals of the alkalies, three series are found, called respectively the principal series and the first and second subordinate series. In each series the lines become closer and closer together with increasing values of m, as in the hydrogen spectrum, approaching a limit (for $m = \infty$) the "convergence-frequency." The red (pairs of) lines of cæsium rubidium and potassium and the yellow sodium lines belong to the principal series for $m = 3$; for $m = 4$ the (pairs of) lines lie in the blue. The arrangement will be clear

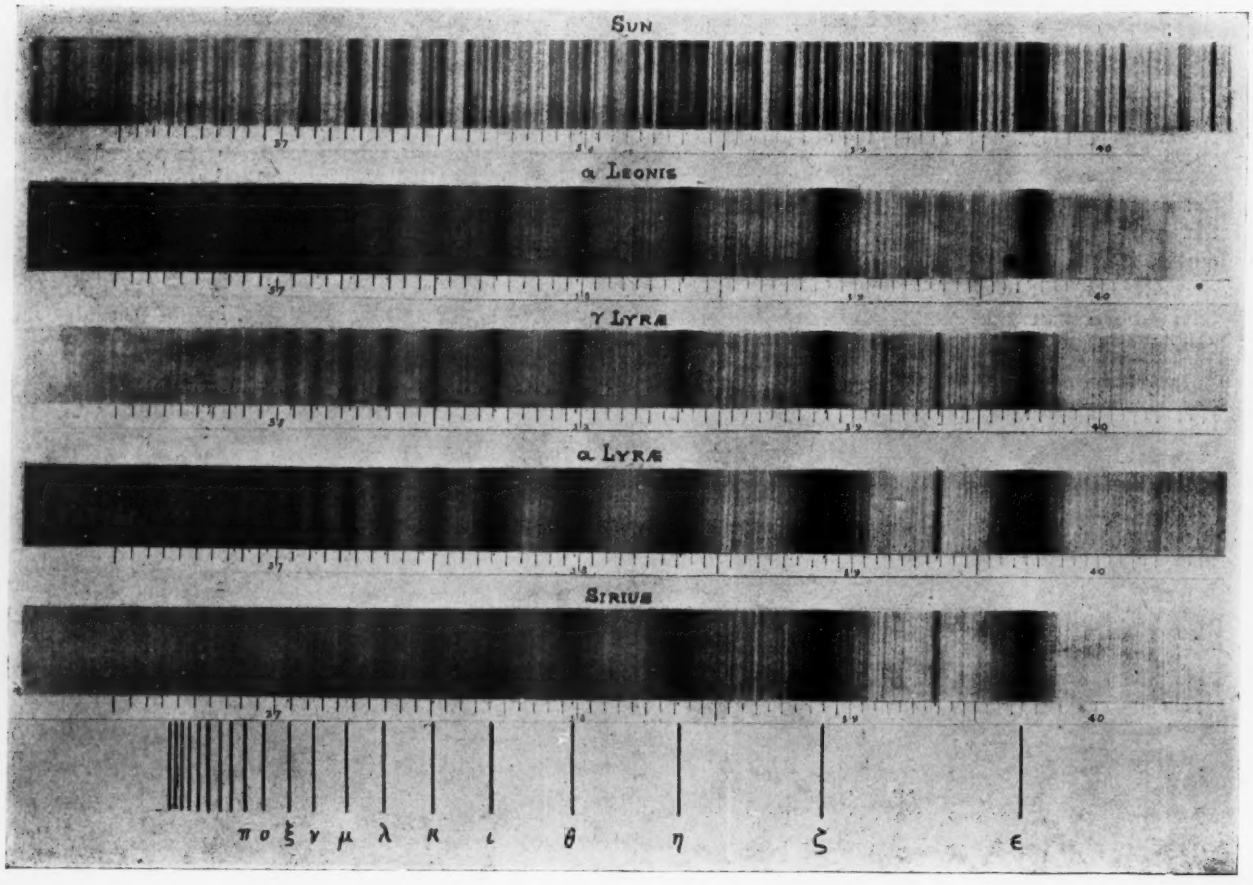


Fig. 1.—Balmer's series of hydrogen lines in Stellar spectra.

from Fig. 2, in which squares of atomic weight are plotted as ordinates on the left-hand edge of the diagram, and oscillation-frequencies as abscissæ along the bottom of the diagram. The red pairs corresponding to m=3 are beyond the diagram to the left; but those for m=4, 5, 6, are shown (Rb_4 is at C.F. 23.7), and the convergence-frequencies (marked $\frac{C.F.}{P.}$) of the principal series in the extreme violet at the right of the diagram. The convergence-frequencies of the two subordinate series (marked $\frac{C.F.}{* \quad \dagger}$) lie nearly together; the positions of the pairs of lines of the *first* subordinate series for m=4, m=5, m=6, and m=7, are shown marked 4*, 5*, 6*, 7*. The lines of the second subordinate series are omitted to avoid complicating the

	Cæsium.	Rubidium.	Potassium.
P_6	27646.66	29841.57	31077.52
	27686.72	29860.91	31082.25

We thus obtain from P_5 { 85.15, 85.11

and from P_6 { 85.75, 85.70

Mean 85.43

The accepted value is 85.5

On examining the diagram Fig. 2 further, we remark that the separation of the pairs of lines 4*, 5*, 6*, and 7* is greatest in the cæsium spectrum, and least in the potassium spectrum, and that the straight lines joining the corresponding pairs in each spectrum seem, in each case, to intersect on the line of zero atomic weight; or, in other words, the separation (of

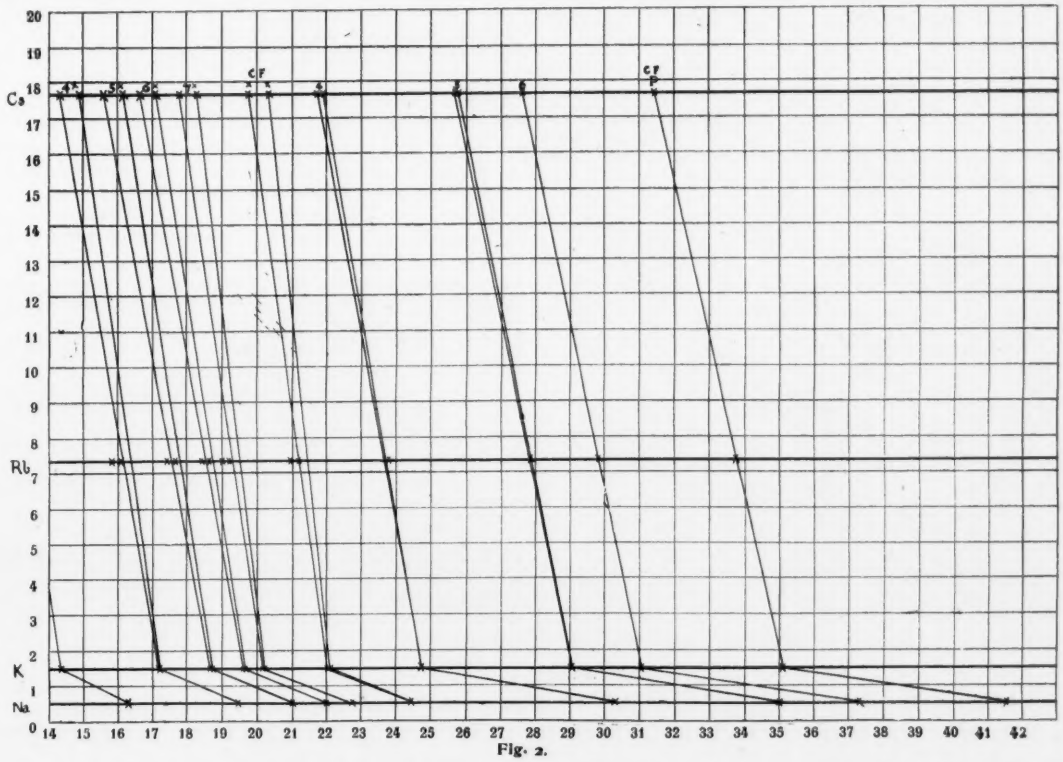


Fig. 2.

diagram. It will be observed that the separation of the lines of pairs is constant in the subordinate series, but not so in the principal series, where they become closer together with increasing values of m.

We remark, further, that in this diagram, drawn with *squares* of atomic weights as ordinates, the straight lines joining the corresponding points of the cæsium and potassium spectra pass through the corresponding points of the rubidium spectrum; pretty exactly in the principal series, but only approximately in the subordinate series. It becomes at once apparent that we can calculate the atomic weight of any one of the three elements from the atomic weights of the other two.

Thus, from the atomic weight of cæsium 132.9, and that of potassium 39.15, we may calculate the atomic weight of rubidium from the following data :—

OSCILLATION FREQUENCIES IN AIR.

	Cæsium.	Rubidium.	Potassium.
P_5	25714.67	27841.66	29006.61
	25794.94	27876.66	29015.03

the lines of a pair) is proportional to the square of the atomic weight. If this be true, we may calculate the atomic weight of any one of the three elements from that of either of the other two. For example, we may calculate rubidium from cæsium from the following data :—

Separation of lines in the first subordinate series.

	Cæsium.	Rubidium.
4*	559	236.3
5*	542.7	236.4
6*	547.0	236.4
7*	549.6	236.7
Means	549.5	236.4

The square of the atomic weight of cæsium is $(132.9) = 17662.41$, and the proportion

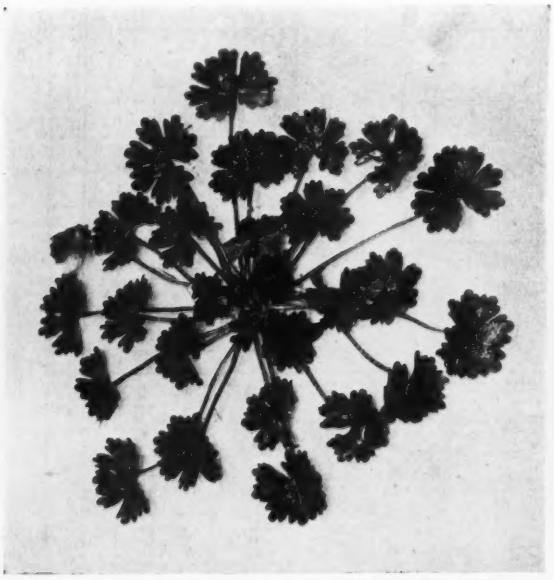
$549.5 : 236.4 = 17662.41 : (\text{At. Wt. Rb.})^2$

gives 87.2 for the atomic weight of rubidium: or, if we take the pairs P_4 in the principal series where the separations are 181.1 and 77.6 respectively, we obtain the value 87.0. *(To be continued.)*

A Plant Life Conundrum.

By G. CLARKE-NUTTALL, B.Sc.

A VERY curious example of plant behaviour under exceptional circumstances came under my notice some time ago, and so far no really satisfactory botanical explanation of the phenomenon has been offered to me, although photographs of the occurrence have been submitted to various botanical experts. Perhaps, however, some reader of "KNOWLEDGE" may be able to provide scientific reasons for the course of action pursued. One may not, of course, at our present state of knowledge credit any plant with *conscious* instinct, or with the *conscious* working out of a plan to meet difficulties even in a case like the present one which would almost seem to challenge our denial of intelligence to plant life.

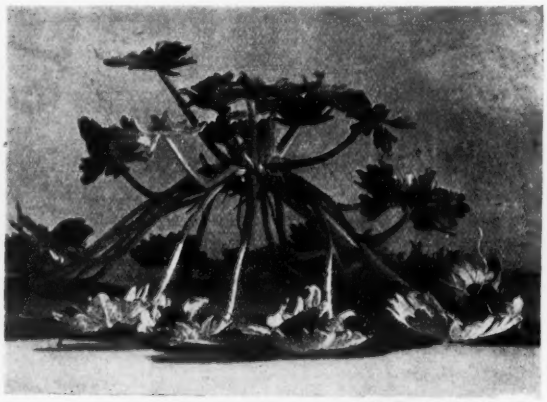


[*G. Clarke-Nuttall, B.Sc.*

Fig. 1.—The rosette formed by a little wild geranium growing flat upon the top of a mossy wall. (Looking straight down upon it.)

The plant in question was a little wild geranium growing, with many others, absolutely flat upon the top of an old wall. The plants were embedded in moss and looked like so many green rosettes lying upon a velvet background. The leaves of each were laid out most symmetrically in the horizontal plane fitting one in with another, each in its appointed place, with longer or shorter stem as necessity required, so that the result was a mosaic with every leaf fully exposed to the light and with no overlapping. The central thick stem was almost suppressed and the root went straight down into the moss. Being at that time particularly interested in leaf arrangement with respect to light my attention was arrested by these plants, and I gently lifted one from the moss, cutting through the stem at the surface of the moss and thus leaving behind a minute remnant of the stem and all the roots. I then carefully carried it home upon a book and at once photographed it to keep a record of the mosaic leaf arrangement. The first illustration shows the position of the leaves, the photograph being taken looking straight down upon the plant.

This done it was then useless further to me, but it was so pretty a thing that I hesitated to throw it away forthwith, so placed it in a little water at the bottom of a deep sponge dish that stood at the back of the washing stand—and absolutely forgot all about it! Two or three days later a friend caught sight of it and exclaimed: "Whatever is this?" I took the dish to the light and at once saw a very curious change had come over my plant. The centre of the plant where the root had gone down into the moss and round which the younger leaves lay had been humped upwards some two inches, and the young central leaves were stretching still further upwards, like arms, towards the light, and were fresh and green with turgid stems. The older leaves which formed the outer ring of the rosette and whose stems were longest had transformed themselves into feet and legs, and had been the means of hoisting the centre of the plant towards the light—no easy task when we consider the short time that had elapsed, the weight of the central portion, the height it had been raised, and the slenderness of the green stems which had taken this unusual task upon themselves. But in so doing they had sacrificed their own well-being, and their power to function as green leaves was fast leaving them, for they were turning a sickly yellow and showed sign of decay. The whole plant now looked rather



[*G. Clarke-Nuttall, B.Sc.*

Fig. 2.—The curious change in the same plant after being left for a couple of days at the bottom of a deep sponge dish in the shade.

like some curious vegetable octopus—but the second photograph will give, better than a verbal description, an idea of its new appearance.

There was no doubt that I was witnessing the last desperate effort of the plant to reach the sunlight from the dark depths of the imprisoning sponge dish, whose shining sides so pitilessly hemmed it in, and thus save itself from death. But how came it that the leaves, all equally fresh and green and functioning alike when the plant was first placed there, were now acting so differently and apparently so rationally in the effort to meet the new emergency? What force was it that impelled the outer leaves to press downwards on the floor of the dish and the *inner* end of their stalks to hoist themselves with their burden upwards, while at the same time the more central leaves were taking a directly opposite course of action? *They* were pressing upwards, not downwards, and it was the *outer* end of their stalks that was in the air. As we only admit blind vital forces acting in plant life—as we do not

recognise the smallest measure of intelligence in plant procedure—how can we reconcile the varying actions of the leaves? It is just the course of action two men would adopt who were trying to reach some point unattainable by either alone. One man would hoist the other on his back, and the second would attain the desired object through the agency and surrender of the first. We know that most leaves and plants have an inherent tendency to grow towards the light—that is, are positively heliotropic—for we have often seen long straggling shoots struggling through the hedgerows to get out into the sunshine. So we should have expected to find that the centre of the plant was lying pressed against the dish bottom while the leaves were *all* being raised towards the light, but apparently only the central leaves now possessed this property, the outer ones having completely abrogated it in the face of the new emergency.

Since the root was entirely removed no radical influence could be exerted, and the water necessary for the central upward-reaching leaves must have been absorbed by the "feet leaves" and transmitted upwards through their stems.

Unfortunately I was unable to watch the further progress of the plant, for I was leaving the hotel at which I was staying and could not carry the plant and dish away with me. So I had to content myself with photographing it in its second curious position, and the two photographs together furnish a complete record of the event, which I venture to call a conundrum in plant life to which experts may, perhaps, suggest some solution.

CORRESPONDENCE.

Physical Constitution of the Moon.

To the Editors of "KNOWLEDGE & SCIENTIFIC NEWS."

SIRS,—I have read with singular interest the letters of Mr. H. L. Meadows and Mr. J. E. Maxwell on the physical constitution of the moon. I can hardly conceive how the conspicuous features of the moon presented to us could have arisen through earth pelting, so graphically described by Mr. Meadows, on account of the individual plastic condition which both bodies would have been in.

Also, I can hardly see how the moon's attraction would have been able to produce the transfer of solid particles from the earth. Would not the earth's superior power at that stage, necessary for the possession of solid particles, retain them? The earth, being the larger body, would not reach that stage until long after the moon had, and the distance then between the two bodies would, I think, be rather considerable.

We also know that the earth would have always had (after the separation) a considerable superiority over its satellite. I think the early condition of the two bodies, as far as we are enabled to conjecture, presents a great barrier to the acceptance of the present condition of the moon—through earth pelting.

I think Mr. J. E. Maxwell's suggestion of meteoric bombardment may probably have been the forces responsible if we look for an exterior cause; certainly we have some evidence that such forces could produce great results. The crater "Canyon Diabolo" does, indeed, present a considerable evidence of a meteoric force. But does not the topography of our satellite exhibit the appearance of latent internal forces that have been at work rather than the varied attacks of meteoric bombardments?

Yours, etc.,

F. F. DAY.

Crowborough.

The Evolution of Sight and Hearing.

By C. F. MARSHALL, M.D., B.Sc., F.R.C.S.

WHEN we consider the extremely complicated structure of the eye and the ear, when we examine by dissection their various parts, and see the great differentiation these parts have attained, it is difficult at first sight to believe that these organs are each developed from a part of the skin. Yet the science of embryology teaches us that this is the case, and that the essential parts of the eye and ear are simply modified parts of the *epiblast*, or skin of the embryo. Further, we can, by comparison with the lower animals, trace these organs backwards as more and more simple structures, till finally, in the lowest animals, they are not represented at all.

The Nature of Light and Sound.—Sound and light are both due to vibrations communicated to the brain by special sense organs, and by an intervening medium. Sound vibrations are slow, travelling only at the rate of 1,100 feet per second, and require a solid, fluid, or gaseous medium to transmit them; they cannot travel in a vacuum. Light vibrations travel much quicker, and are transmitted by the invisible hypothetical æther. Light can travel in a vacuum, thus differing from sound.

The Appreciation of Sound and Light.—The skin is sensitive to vibrations, and in the lower animals, in

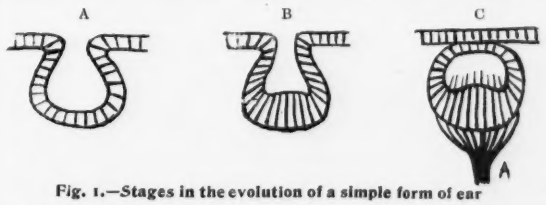


Fig. 1.—Stages in the evolution of a simple form of ear

A.—Involution of epiblast forming a pit. B.—Modification of the cells at the bottom of the pit. C.—Closure of the pit to form a sac. The special cells (auditory cells) have become connected with the auditory nerve (A), and are furnished with hair-like processes which communicate vibrations of sound to the cells, and so to the nerves.

which there are no organs of sight or hearing, vibrations can be felt by the skin. Thus Darwin showed that the earth-worm, when placed on a piano, was sensitive to the vibrations, but had no appreciation of different sounds. It would clearly be an advantage to an animal to have some parts of the skin modified to appreciate vibrations more acutely, and to be sensitive to the vibrations of sound or light. An animal thus provided would be able better to escape its enemies and to obtain food. Thus by evolution have arisen the eye and the ear. Certain cells of the skin were more sensitive than their fellows to vibrations of light and sound, and the animals possessing this advantage had a better chance of surviving than the others, and so transmitted the peculiarity to their offspring, in which it was intensified. So these cells became more and more modified as we pass upwards in the animal kingdom, till the elaborate structures of the ear and eye of man are attained.

The Ear.—We have seen that the ear arose from certain cells of the epiblast, or skin, becoming modified so as to better appreciate the waves of sound. Let us see what this modification consists of. The simplest form of ear is that found in certain jellyfish or medusæ. This is a small sac, sometimes open externally, sometimes closed, and consisting of modified epithelial cells. At one place these cells are more differentiated and furnished with hair-like processes at their free surfaces; at their deeper surfaces they are connected with nerve

filaments connected with the nervous system. The sac is filled with fluid, and usually contains calcareous concretions called *otoliths*. Vibrations of sound falling on this organ are transmitted by the fluid contained in it to the hair-like processes of the cells, aided, perhaps, by the calcareous otoliths, and thence, by the nerve filaments connected with the cells, to the nervous system.

Here we have all the essentials of an organ of hearing, and the complicated ear of the higher animals, including man, is in its early stages of development, as revealed by embryology, essentially the same, *i.e.*, a sac of epithelial cells formed from the epiblast. This sac, in the higher animals, becomes much convoluted and differentiated, and is known as the internal ear. This is too complicated to consider in detail in this paper, but it will suffice to state that it consists of a sac, the *vestibule*, connected with which are three *semi-circular canals*, and the *cochlea*. Specially modified auditory cells are present in each of these parts and are connected with the auditory nerve. The cochlea is a spiral tube, along which run rows of special cells of peculiar shape, forming the *organ of Corti*. These cells are supposed to be the chief means of transmission of sound vibrations to the auditory nerve and so to the brain.

In addition to this there are certain accessory organs, the tympanic membrane and the three small bones called the malleus, incus, and stapes. The *tympanic membrane*,

Fig 2.—Diagrammatic and simplified view of arrangement of ear in man.

A.—Auditory canal. T.—Tympanic membrane. M.—Middle ear, containing the three small ossicles, represented here as one for the sake of simplicity. P.—The perilymph surrounding the internal ear. E.—Endolymph. B.—Brain, from which is seen the auditory nerve passing to the special cells of the internal ear.

or drum of the ear, is situated at the bottom of the auditory canal leading from the external ear. Vibrations of sound transmitted to this membrane cause it to vibrate; these vibrations are communicated by the chain of small bones to the internal ear, or vestibule, to the *perilymph*, a fluid intervening between the internal ear and the bony part of the skull in which it lies. By this means the sound vibrations are conveyed to the *endolymph*, the fluid inside the internal ear, and so to the special auditory cells in the cochlea and other parts of the ear, and by these to the auditory nerve and the brain.

The Eye.—The eye is also developed from a modification of the cells of the epiblast. The evolution of the eye is well shown in the molluscs, and several animals of this group are known which represent the several stages in the evolution of the eye. The simplest form of eye in this group is simply a small pit in the skin, the cells at the bottom of which are modified slightly and can appreciate light from darkness. Such a form of eye is found in the *Solen*. A slight advance is met with in the Limpet (*Patella*), where the pit is deeper and the cells more modified. The next stage consists in narrowing of the opening of the pit; in conseqeunce of this a slight image is formed, because light from an object can only fall on one particular part of the pit. This form of eye is found in *Haliotis*. A further advance is found in Fissurella, in which animal a *lens* is developed. By the lens a much more distinct image is obtained by focussing the rays of light on the sensitive cells (or retina). In higher forms of molluscs, as the cuttlefish, the eye is more perfect, resembling superficially the eye of the vertebrate animals in having an iris and eyelids, and a protective coat, the sclerotic, surrounding the sensitive cells or retina. It is interesting to note that the eye of the cuttlefish during its own development from the embryo to the adult passes through stages corresponding to the various stages in the evolution of the eye met with in the adult animals we have mentioned above.

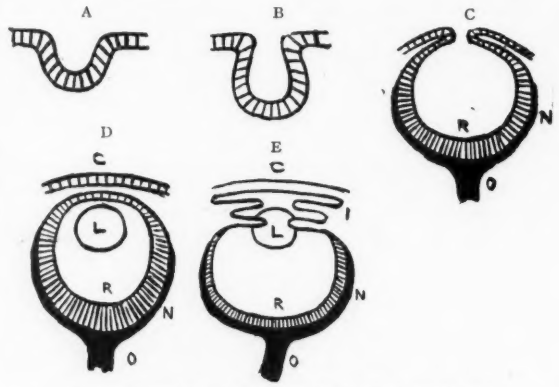


Fig. 3.—Stages in the evolution of the eye of molluscs.

A.—A simple involution of epiblast (*Solen*). B.—Narrowing of the mouth of the pit (*Patella*). C.—Further narrowing of pit. Presence of a definite optic nerve (O) and nerve layer (N) surrounding the sensitive cells, or retina (R) (*Haliotis*). D.—Closure of pit forming a sac. Development of lens (L) (*Fissurella*). E.—Formation of cornea (C) and iris (I) (*Cuttlefish*).

The essential part of the eye, the retina, in the above cases is developed directly from the skin, or, in other words, the retina is formed by an involution, or pitting in, of a patch of epiblast; the lens is formed by a deposit of cuticular matter. In the vertebrate eye the development is different, the retina is developed as an outgrowth from part of the brain, the lens being formed from an involution of epiblast. This difference, though apparently so great, is, in reality, not so, for the brain itself is developed from the epiblast of the embryo, and so the retina is, after all, a modified piece of epiblast.

In conclusion it is necessary to state that the nervous system and brain develop with the sense organs, for without a nervous centre capable of appreciating sensations of light and sound the eye and ear would be useless. It is the brain which is the seat of the sensations of sound and light, as of all other sensations. The eye and ear are simply accessory organs which transmit the vibrations of light and sound to the brain.

The Société astronomique de Montpellier" has published a small pamphlet, entitled **L'Enseignement de l'Astronomie Elementaire par l'observation directe du ciele** by one of their Secretaries, Professor Marcel Moye, which might serve as an excellent model for some of the "Nature studies" which are gradually taking a more assured place in the curricula of our schools. Maps giving the portion of sky visible at four different sidereal times, with indications as to when they are visible (*e.g.*, the first gives the naked-eye view for December 1 at 9 p.m. and January 1 at 7 p.m.), are followed by simple instructions for the demonstration of the diurnal rotation and annual revolution of the earth and the movements of the moon and planets, without the aid of any instrument. The actual letterpress only occupies eleven pages, so that no fault can be found on the score of prolixity, and for its purpose, the popularisation of the elementary study of the sky, it is admirable.

Otoliths.

By COLONEL C. E. SHEPHERD.

WHAT are they? The word, derived from the Greek "otos," of an ear, and "Lithos," a stone, explains itself. They are stones found in the membranes of the ear. In the mammalia they are small, in man very minute; in birds they are larger, but in those fishes that have a bony skeleton they grow to an appreciable size, and in some instances may be called large, as in the case of the hake, cod, and haddock, illustrated further on. The seal, a mammal living in the water, has otoliths of considerable dimensions. The otolith, unknown by the general public, is known to people who deal with fish and to cooks; they are called by some the "ivories" of the fish, and by others the "ear bones."

The term "ear bone" is a misnomer; they are not like true bone, but are mostly composed of carbonate of lime, dissolving in acid with a brisk effervescence. Otoliths rather resemble shells, and in texture are analagous to the enamel of teeth.

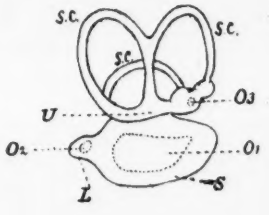
There is a certain resemblance between the membranes of the human ear and those of a fish's ear, as the two following diagrams show:—

Diagram of Human Ear Membranes, much enlarged.

AFTER WALDEYER.

S. Sacculus. U. Utriculus. S.C. Semicircular Canals. D.C. Ductus Cochlearis.

Diagram of Membranes of a Fish's Ear, much enlarged.



AFTER KOKEN.

S. Sacculus. U. Utriculus. S.C. Semicircular Canals. L. Lagena, considered a rudiment of the "Cochlea." O1. The largest Otolith, called the Sagitta, is in the Sacculus. O2. One of the smaller size, the "Asteriscus" is in the "Lagena." O3. Another of small size, the "Lapillus" is in the "Recessus Utriculi."

In the Carp family and a few other fishes the otolith of the Lagena is the largest. In the Siluridæ the Lapillus is the largest of the three and most solid. In both these species the Cyprinidæ (carps) and the Siluridæ, the Sagitta is represented by a rod-like otolith, and this and the Asteriscus are embedded in the bone of the skull, which has to be carefully cut away to get at them. Compared with man the sacculus in the fish is more developed, but the utriculus is less so, and in the fish the cochlea is rudimentary. There are three otoliths in each side of the head of a fish, or a total of six in all. Those fishes that have only a cartilaginous skeleton, such as sharks, the skate, and the rays, have no solid otolith; its place is taken by a white calcareous powder known as "Otoconie" ear-dust. The otolith was known to the writers of ancient times, being mentioned by Aristotle and Pliny. In mediæval times they were used as amulets; people imagined that they had mysterious powers against all possible injury to the body; the fervid imagination of superstitious persons seeing in the markings of the central furrow of the cod's otolith a representation of the Virgin. In the otoliths of some of the Sciænidæ, a class of fish found in the Mediterranean and in the Indian Ocean, they saw marks to represent a key; this they connected in imagination with the Keys of Heaven and thus with St. Peter. These otoliths were known as "Peter Stones." In the Apothecaries' shops of olden times otoliths were displayed, labelled "*lapides percarum*," "very costly stones." They were prescribed particularly for colic and for headaches. In Madras at the present day they are considered by some people as being good for sore eyes if rubbed over the surface of the closed eyelid or tied on to it. Some of the views on otoliths, held even by men of science of past times, such as Rondelet and Aldrovendi, were equally astonishing. They recorded that these stones in the fish's heads often caused their death because, in winter, they attracted the cold and so made the brain freeze.

That the otoliths have to do with the hearing powers of the fish is most probable from their position in the skull and their location in the membranes of the ear. The nerve filaments, however, do not touch the otoliths or spread themselves on them. These stones, then, are not of primary importance to the hearing of the fish, but would seem to be an important secondary apparatus, serving to strengthen the vibration of sounds taken up by the hearing organ's labyrinth's fluid, the endolymph, which fills the vestibule and surrounds the otoliths. This elaborate provision in the organs of hearing of the fish points to its having that sense finely developed, an idea that generally does not enter the heads of most people, who look upon fish always as being deaf, an idea probably due to fishes, except in a few exceptional cases among the sharks and rays, having no external opening for the ear.

Otoliths are found in the fossil state in many places in England, notably in the gault at Folkestone, and are also found in the tertiary rocks of the Austro-Hungarian Empire and in similar rocks in Italy.

Fish otoliths, whilst varying between themselves both in size and form for the different kinds of fishes that possess them, yet in both respects show a remarkable constancy in the same kinds of fishes of which they are characteristics; so much so that it enables men of science to name the extinct fish of which a fossil otolith is found if in good preservation. These fossil otoliths resemble the otoliths of allied species of fish of the present day.

The fossil otolith of *Gadus elegans* shows the characteristic appearance of the family of the Gadidæ, and is very like the otolith of the "Whiting pont" of present times, the *Gadus luscus*.

Scientific commissions, in various countries, are now employed investigating the life history of the fishes of the North Sea, more especially those fishes used as food by man. One result of their researches is that the age of some fishes may be deduced from the number of rings visible in their otolith. The following is a copy of the remarks on this point placed above the case showing the growth of the plaice in the Central Hall of the British Museum, Natural History, South Kensington, London:—

"The age of the fish is determined by the number of

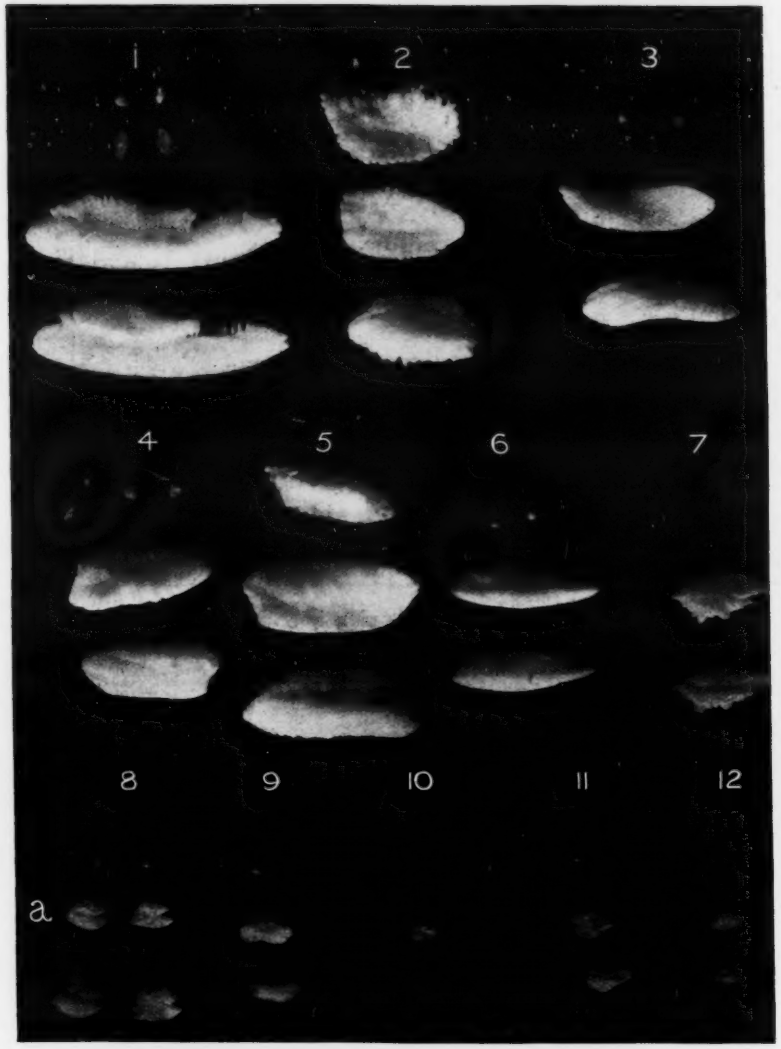


Fig. 1.

Otoliths of 1. Hake, *Merluccius vulgaris*. 2. Cod, *Gadus morrhua*. 3. Coalfish, *Gadus virens*. 4. Pollack, *Gadus pollachius*. 5. Haddock, *Gadus aeglefinus*. 6. Whiting *Gadus merlangus* 7. Sea bream, *Pagellus centrodontus*. 8. Gurnard, *Trigla cumardus*. 8a, Red Gurnard, *Trigla pini*. 9. Grey mullet, *Mugil capito*. 10. Red mullet, *Mullus barbatus*. 11. Salmon, *Salmo salar*. 12. Salmon trout, *Salmo trutta*.

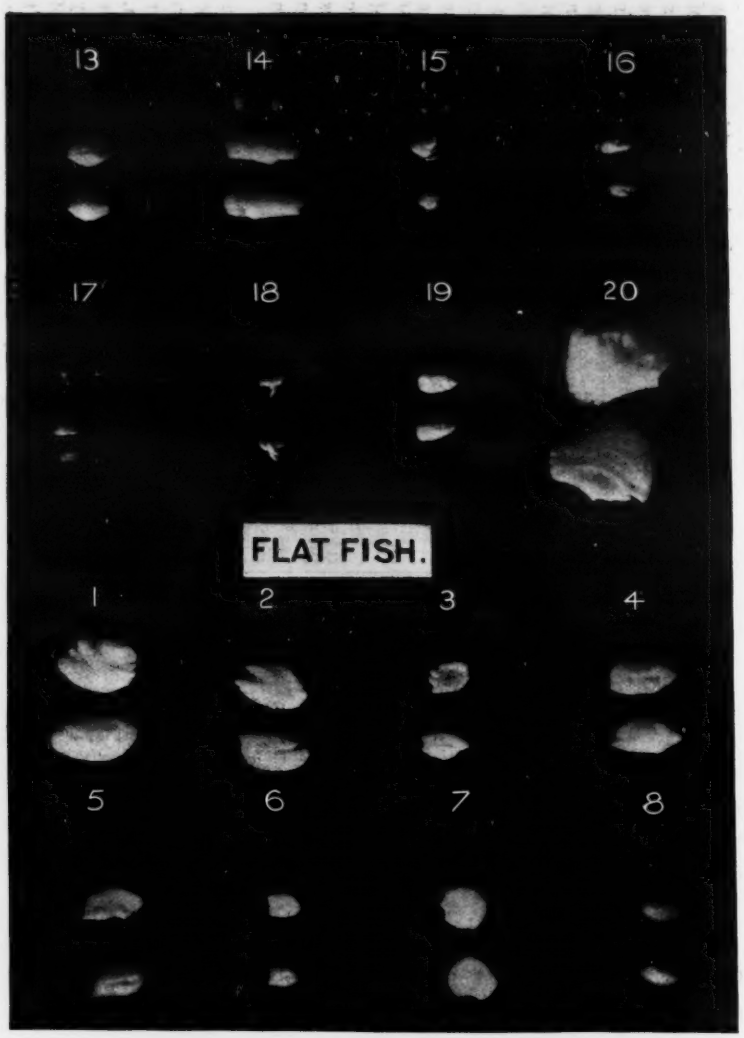


Fig. 2.

Otoliths of 13. Smelt, *Osmerus eperlanus*. 14. Conger, *Conger conger*. 15. Eel, *Anguilla anguilla*. 16. Herring, *Clupea harengus*. 17. Mackerel, *Scomber scomber*. 18. John Dory, *Zeus faber*. 19. Garfish, *Belone belone*. 20. Deep sea bream, *Beryx splendens*. FLAT FISH.—1. Halibut, *Hippoglossus vulgaris*. 2. Turbot, *Rhombus maximus*. 3. Brill, *Rhombus laevis*. 4. Plaice, *Pleuronectes platessa*. 5. Flounder, *Pleuronectes flesus*. 6. Sole, *Solea vulgaris*. 7. Lemon sole really dab), *Pleuronectes cynoglossus*. 8. Sand dab, *Pleuronectes limanda*.

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rings visible in its otolith or earstones. A white ring is formed in the spring of each year of the life of the fish, and a dark ring in the summer and autumn. But little addition is made to the earbone during winter. The age of the fish is reckoned from the February or March of each year, the height of the spawning season, and the number of white rings outside the white centre give the number of complete years which the plaice has lived."

The Museum of the College of Surgeons has some otoliths beautifully set up showing their position in the membranes of the ear and relatively to each other.

The next two illustrations show the otoliths of some of the more common fishes of the present day—actual size.

No. 1 shows all six of the otoliths from the hake. Under Nos. 2 and 5 the upper otoliths are of another fish to the lower pair and introduced as being abnormal. The small otoliths are the Lapilli of the species.

In the species to which the cod belongs, the Gadidæ, the otolith is contained in a well-defined pocket.

In the whiting this pocket can be looked into from the underside of the skull, the back part behind the palate of the fish; the bone there is very thin and the otolith shows as a dull white object on each side of the centre line. This is only visible in the uncooked state. The otolith lies with the pointed end in the direction of the fish's body, and it is partly tilted up so as to lie on its edge.

In flat fishes the skull is much distorted. The pockets containing the otoliths seem to lie one above the other. The bone is very thin over the pockets in the brill and lemon sole.

From the illustrations it is easy to see how some small fishes, the smelt, for instance, have a comparatively large otolith; the mackerel and herring, both much larger fishes, have, however, smaller otoliths. The size of the fish, then, is no indication of the size of the otolith. The John Dory has a most curiously shaped otolith, and very small for the size of the fish.

In the illustrations of the present day fishes the otoliths are turned one each way to show the markings on the two different faces and the furrows, the *Sulcus acusticus*, that some have so very well defined (see lower examples Nos. 7 and 11 and Nos. 2 and 3 in flat fishes).

Occasionally a malformation of the otolith is met with; one otolith may be normal, the other, in the same fish, abnormal both in shape and texture; the porcelain china look of the normal one being replaced by a frosted glass appearance in the texture. The upper one illustrated in the haddock is thus abnormal, the centre has the porcelain look, but the back and edges in the original have the frosted glass look. The upper one of the cod's illustration is abnormal in having edges more, as it were, ornamental than usual.

In these days of "collecting crazes" some may like to take up the collecting of otoliths; the subject is interesting in itself and leads to acquiring a knowledge of fishes and their peculiarities which would otherwise never strike attention.

The *Daily Telegraph* last year, under the heading "Topics of the Hour," began a paragraph with this statement: "This is an age of superstition. Everyone you meet is wearing some jewel or other of occult power. A fish otolith, that of a cod, for instance, set as a charm would probably be as efficacious in warding off bodily injury, as our ancestors thought, as any other charm, and be far cheaper. Some of the present day superstitious folk might try, it can do them no harm, and there are so many motor cars about."

Ant-Gardens and Ant-Hotels.

By RUDOLF BEER, B.Sc., F.L.S.

IT is difficult for us who live so far away, and under such different circumstances, to realise the enormous influence that the leaf-cutting ants exert upon the vegetation of the Western tropics. Horticulturists from South America tell how impossible it is to introduce many fruit trees and vegetables into those countries solely because they are destroyed by the leaf-cutting ants as soon as they are planted.

To anyone who has had the opportunity of watching the restless energy which the countless hordes of these tiny animals display, it is a matter of wonder that a leaf is left upon any plant. It is partly owing to the wonderful exuberance of a tropical forest that the trees are not all stripped entirely bare, but it is more often due to various protective adaptations that the plants escape destruction. To these adaptations we will return in a later section of this paper. One of the most vivid descriptions of the leaf-cutting ant which we possess is to be found in that classic of natural history—Thomas Belt's "The Naturalist in Nicaragua" (1874). In this work Belt describes how the tracks of the leaf-cutting ant spread in every direction through the forest. Over these paths two great armies of ants constantly move; one hastening away from the nest into the forest, the other returning to its home laden with a piece of leaf about the size of a sixpence. If one of the ants hurrying from the nest be followed it will be seen to ascend some distant tree or bush, and, with its scissor-like mandibles, to cut a slice from a leaf, with which it hurries away. So numerous and so active are these ants that in a very short time nothing is left on the tree but the leaf-stalks and some of the harder ribs of the leaf. The tracks of the ants often range for more than half a mile from the nest. Besides his splendid observations upon the work and habits of these ants outside the nest, Belt has guessed with wonderful acumen at their behaviour within their home and the use they make of the leaves they so laboriously cut and carry to their abode. So extraordinary and so improbable, however, did this guess seem that very little credence was given to it until the whole subject was re-opened by the exhaustive labours of Alfred Möller* in Brazil.

Möller was stationed at Blumenau, and here he found the most common species of leaf-cutting ant to be *Atta discigera* (Mayr). *Atta hystrix* (Latr.) is almost equally abundant, whilst *Atta coronata* (Fabr) is much rarer. Another species of *Atta* which Möller provisionally calls *Atta IV.* is occasionally met with in the woods round Blumenau, but it forms only small colonies.

The paths which these ants make (speaking here of *A. discigera* in particular) are beautifully smooth and form little hollowed-out channels, over half an inch across, which extend in all directions from the nest. One path Möller traced for upwards of 26 yards across a meadow. Most of this path was completely hidden and protected by the grass, but wherever it was left exposed the ants had roofed it over with an earthen cover. Besides the ants which were carrying leaf-fragments and those which were hurrying away to fetch fresh loads, others were seen moving, in an apparently aimless fashion, along this path. When, however, any spot on the road was broken down or an obstacle placed on the path, whilst the leaf-carrying ants tried to find a way round it, the aimlessly-moving

* His work is recounted in "Die Pilzgärten einiger Sud amerikanischer Ameisen." Gustav Fischer, 1863.

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ants suddenly showed a purpose in their movements and hastened to the obstructed spot, where they formed a regular breakdown gang, building up the broken way or removing the obstacle in a very short time. Möller and a friend who was with him watched the journey of one particular ant which was carrying a load that weighed about double its own body weight. They found that it travelled over the 26 yards in about 1 hour 10 minutes.

The actual cutting out of the leaf-fragment was repeatedly watched by Möller with the aid of a magnifying lens. The ant sits on the piece of leaf that it is cutting away and uses its mandibles as scissors; all the time that this is going on it turns itself slowly about on its hind legs. As it sits upon the slice of leaf which is being cut out it looks as though the ant must fall to the ground together with its burden, but just at the last moment it is seen that the little animal has stretched out one of its fore feet with which it grasps the attached leaf and that, although at the moment that the fragment of leaf is detached the ant appears in a perilously uncertain position, it almost immediately rights itself and hoists up its load into a convenient position and then it hastens upon the return journey to its home.

The weight of the load carried by the ant was several times ascertained. As a rule it is from one and a half to two times the weight of the ant, but in other cases it is much heavier. In some extreme instances it was found that an ant was carrying a burden nine times its own weight!

The nests of *Atta discigera* and *A. hystrix* are rarely built in the open. In such cases they are seen to be bluntly pyramidal structures the surface of which is made up of pieces of dried leaf and stick. In nearly all cases, however, the nests are formed in little natural hollows which may be enlarged to a suitable size by the ant. One large nest had been built under the stone steps of the house in which Möller was staying.

Inside every nest, wherever and however built, there is always a loose, soft, grey, flocculent, porous mass which is channelled and hollowed like a sponge. This mass was called "ant food" by Thomas Belt, and the "Pilzgarten" by Möller. I will call it the *ant-garden* in the present paper.

This ant garden contains the eggs, larvæ, and pupæ of the ants in its pores and passages; it is always free from the walls of the nest, but is never found uncovered. *Atta coronata* usually builds its nests underground, and not infrequently it bores for more than a yard below the surface before it constructs its "garden."

The nests of *Atta IV.* are similar to those of *A. discigera*, but on a smaller scale. If a fragment of the ant-garden be broken off and examined under a lens it will be seen to be composed of numberless little soft pellets, each about $\frac{1}{50}$th of an inch in diameter, which build up the garden like bricks do a house. These pellets, when they are quite fresh, are dark green, older ones are almost black, whilst very old ones are yellow-brown in colour. They are interwoven with the threads of a fungus, and it is these threads which take the place of mortar and bind the pellets together into the mass of the ant-garden. Spread over the entire surface of the "garden" are an enormous number of little, round, white bodies varying from between $\frac{1}{50}$th and $\frac{1}{100}$th of an inch in diameter. Möller has called these the *Kohlrabi-heaps*. These "Kohlrabi-heaps" are part and parcel of the fungus which interweaves the pellets of the garden and under the microscope are seen to be little round swellings upon the superficial threads of the fungus.

As was pointed out at the beginning of this paper, it has been well known for many years that these ants cut and carry fragments of leaves to their nests. The number of leaf-fragments which thus reach the nest is very large. Möller observed 217 loaded ants to pass one point on a path leading to the nest in a quarter of an hour, and in Nicaragua the number of ants which move along the tracks is far greater. In spite of this no leaf-fragments accumulate in the nest itself, and their fate has been the subject of much wonder and surmise to many naturalists. Some have believed that the ants eat the pieces of leaf, others imagined that the nest was built of these fragments, and, finally, Thomas Belt hazarded a guess of the most sensational character as to the use which was made of the pieces of leaf.

He believed that the leaf-cutting ants were gardeners and that they actually prepared beds with the leaf-fragments that they brought to the nest, and that upon these they grew a fungus for their food. "I believe," he writes, "that they are, in reality, mushroom growers and eaters."

Belt's supposition was of so remarkable a character and he was able to bring forward so few facts to support it that, although it attracted a great deal of attention, it found but few adherents.

Möller, armed with the resources of a splendidly-equipped laboratory, attacked the problem with an ingenuity of mind and an untiring enthusiasm which must win for him our highest admiration.

That the ant-garden is greatly valued by the ants is shown by the scrupulous care with which they gather up every fragment of a "garden" that has been removed from a nest and scattered on the ground. If a nest is several times disturbed its inhabitants will desert it and make their home elsewhere. When this is done, however, they carry with them not only their eggs and larvæ, but every morsel of the "garden." Möller next examined the ant-garden microscopically, and he was able to ascertain that the pellets of which it is built consist of torn shreds of leaf. Stomata, epidermal cells, and chlorophyll grains could all be seen in these pellets. There was strong reason to believe, therefore, that some, if not all, the pieces of leaves which are carried to the nest are shredded out and worked up into these tiny little soft building-stones of the garden.

The next step which Möller took was the attempt to keep the ants in captivity under such conditions that he could constantly watch their operations.

After many failures he at last succeeded in this attempt.

In a covered glass basin he placed a few workers of *Atta discigera* or *A. hystrix*, and, after crumbling up a piece of "garden" to tiny pieces he scattered these over the bottom of the basin. The ants at once set to work at the pieces of garden, and within 12 hours they had reconstructed a new garden. All bits of dirt or other foreign matter were carefully separated and set on one side. Continuing his observations on the following days, Möller noticed that the older pellets, upon which the fungus no longer grew, were removed from the garden and added to the heap (or, rather, layer) of refuse. As this goes on the nest becomes smaller and smaller until at last nothing is left of it. The ants then run aimlessly about, and after eight to 14 days they are all dead. From this it is seen that the life of the ant is bound up with the existence of the "garden."

In another experiment a little moist sand was placed in the glass vessel, a few leaves of a plant the ants usually "cut," and a certain number of ants. The ants burrowed into the sand, but never touched the leaves. After some days' starvation a small fragment of "garden" was introduced into the basin. An ant

moved to it, and, after examining it, hastened under the sand to return almost at once accompanied by the other ants. These all hurried to the "garden," and, watching them under a magnifying glass, Möller could see that they greedily tore off and devoured the Kohlrabi-heaps of the fungus. Again Möller starved ants for several days and then presented them with the Kohlrabi-heaps of the fungus upon the end of a needle. These they at once seized and ate.

Finally Möller kept a number of ants in a glass basin, together with the fragments of a "garden" and several leaves from a tree which he knew them to attack.

The "garden" was rapidly reconstructed and constantly purified of old pellets. As the garden decreased in size some of the ants set to work upon the leaves, and he was able to watch them, step by step, cut slices from the leaves and tear, chew, and pound these up and finally work them into a pellet which they added to the "garden." It took an ant a quarter of an hour to prepare such a pellet. After the pellets have been inserted into the garden it is perfectly wonderful how quickly it becomes interwoven by fungal threads from neighbouring pellets. Pieces of leaves which had been cut and pounded up in the morning were already interwoven by the fungus in the afternoon.

By these experiments Möller was able to substantiate the hypothesis of Belt and to clear up in every particular the wonderful operations that proceed within the nest.

Moreover, further observations showed Möller that there were special "gardener" ants living within the nest. These ceaselessly weeded the garden so that no foreign fungus or bacterium could spring up. Only those who have attempted to keep a culture of any fungus pure realise the difficulty of doing so. The spores of the various moulds and bacteria are omnipresent, and a single unguarded moment suffices for these to enter the culture and render it impure. Nevertheless, in the face of all these difficulties the ant-gardeners succeed in growing only the one fungus which serves them for food and eliminating all other organisms. If a piece of "garden" is kept in the glass basin with only a very few of these gardener-ants the threads of the fungus begin to grow out into the air. The ants at once "prune" these aerial branches off; but as so few ants are present they cannot work quickly enough, and before long such a forest of fungal air-threads have grown up that the ants can no longer move through the dense jungle.

What we have learnt, therefore, of these leaf-cutting ants is that some travel far afield from their homes to fetch leaf-fragments, which are specially prepared and worked up into a "bed" upon which a special fungus can grow; that other ants are road-menders, repairing and overseeing the paths along which the leaf-cutters must travel; whilst other workers stay within the nest as "gardeners," who weed the fungus-beds and prune the plants which they have in their charge.

The following pages of Möller's book are of the highest importance to the special student of Fungi, but we must hurry over them with a mere reference. He succeeded in growing the fungus of the ant-garden in artificial cultures, and he discovered that several secondary fruit-forms were developed by this plant. Moreover, he was able to induce it to produce the "Kohlrabi-heaps," which are the special food of the ants. These Kohlrabi-heaps are formed by the ends of the threads, which swell up into little round bladder-like structures filled with protoplasm. Another important discovery was that of the primary fruit-form, which showed the fungus to belong to the Agarics (to which the mushroom and toadstools also belong). The genus under which it must be classified is that of *Rozites*, and Möller names the fungus *Rozites gongylophora*.

Möller concludes his work with a description of the fungal-gardens of two other genera of ants—the Hairy-Ant (*Apterostigma*) and the Hillock-Ant (*Cyphomyrmex*), but I have no time to say anything of these, except that they are both "gardeners," but neither leaf-cutters. They build their nests in rotten wood and construct their "gardens" of the wood-meal and excrements formed by insects (beetle-larvæ, etc.) which burrow in the decayed wood.

In an earlier part of this paper I have attempted to make clear to you the enormous damage that these leaf-cutting ants can work upon the surrounding vegetation. It now remains for us to enquire why it is that certain plants remain untouched by these ants, whilst others are entirely destroyed by them.

In some cases it is the oily or resinous secretions* contained in the plant which gives them immunity from the leaf-cutting ants, but there are other plants which have no such secretions and in which the leaves appear most suitable for "cutting," but which are, nevertheless, untroubled by these pests of the tropics.

Before we can understand the reason for this immunity enjoyed by certain species of plants it must be pointed out that the leaf-cutters are not the only kind of ant inhabiting these countries. There are as well other genera, many of which are distinguished by their warlike habits.

Bates, in his delightful book, "The Naturalist on the River Amazon," has described the triumphant progress of an army of ants belonging to the genus *Eciton*. The approach of a column of these ants is heralded by the restless flight of birds. As soon as an Indian sees these birds he takes to his heels, but the less wary European, not understanding the meaning of these signs, will probably be overtaken by the ants, which will cover his body in thousands, and, fixing themselves to his skin with their mandibles, will sting him from head to foot. Every caterpillar, or spider, or other ant which falls across the path of these fierce warriors is immediately set upon. They will attack a wasps' nest without the least hesitation, and, tearing it to pieces, will drag out the soft larvæ quite regardless of the furious insects which buzz around them.

It is a very old observation that some genera of these fighting ants inhabit hollow cavities in certain species of plants. Thus, as long ago as 1688 John Ray found the hollow stem of *Cecropia palmata* inhabited by ants. In 1763 Jacquin related that when a bush of Acacia was touched an army of furious ants rushed out from its interior. In 1750 Rumphius found the tubers of *Hydnophytum* and *Myrmecodia* to contain warlike ants. It was Thomas Belt, however, who first interpreted these facts correctly. After describing certain points in the structure of *Acacia cornigera* he concludes by saying: "I think these facts show that the ants are really kept by the Acacia as a standing army to protect its leaves from the attacks of herbivorous mammals and insects."

Many have studied this subject since Belt's time, but they all confirm his conclusion, and the work of Schimper, perhaps more than that of anyone else, has finally and conclusively shown that the immunity which certain plants possess from the leaf-cutting ant is due to the presence of warrior-ants in their interior who

* The smooth, waxy surfaces of the stems of some plants afford no foot-hold to the ants, and are thus protected.

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drive off any leaf-cutter who attempts to set foot upon the plant.*

One of the earliest known and most thoroughly studied cases of plant-hospitality towards their soldier guests is that of the Trumpet-tree (*Cecropia*).

If one of these trees is somewhat roughly handled an army of ants rushes out from little holes in the stem and fiercely attacks the aggressor. The ants inhabiting *Cecropia adenopus* always belong to the same species, *Azteca instabilis*, and they are among the most warlike of the ants to be met with in Brazil. A tree provided with an army of Azteca ants is never touched by the leaf-cutting ants.†

In those rare cases, however, in which for some reason or other the tree is left without its soldier-guests, the leaf-cutters at once set to work on its leaves and very quickly demolish them. In exchange for the very valuable service that the Azteca ants perform for the Trumpet-tree this provides the ants both with shelter and with food. The stems of *Cecropia* are hollow and partitioned up into little chambers by very thin diaphragms. Each of these diaphragms is bitten through by the ant, so that all the chambers communicate with one another.

Above the place at which a leaf is inserted on the stem a specially thin spot, composed of only soft tissues, is left. This thin region is easily perforated by the ant, which is thus furnished with a door into its abode above every leaf.

At the base of each leaf stalk is a patch of brown, velvet-like hairs, between which curious little white, egg-shaped bodies lie. These little bodies were first noticed by Fritz Müller, and are called after him "Müller's bodies."

They form the staple food of the ants, and, consisting of soft parenchyma-cells rich in proteids and fatty matters, they are no doubt highly nutritious.‡

The Acacias are, for the most part, prickly shrubs or small trees. Usually the prickles are small and solid, but in some instances they are both large and hollow.

When this is the case the prickles are nearly always inhabited by ants. *Acacia sphærocephala* (Willd.) is a not uncommon bush in Mexico, Central America, and the Greater Antilles. The relation of this shrub to ants was first described by Thomas Belt.

"The thorns of the bull's horn Acacia," he writes, "are hollow, and are tenanted by ants that make a small hole for their entrance and exit near one end of the thorn, and also burrow through the partition that separates the two horns, so that one entrance serves for both. Here they rear their young, and in the wet season everyone of the thorns is tenanted, and hundreds of ants are to be seen running about, especially over the younger leaves. If one of them be touched, or a branch shaken, the little ants (*Pseudomyrma bicolor*, Guer.) swarm out from the hollow thorns and attack the aggressor with jaws and sting. They sting severely, raising a little white lump that does not disappear in less than twenty-four hours. They form a most efficient standing army for the plant, which prevents not only the mammalia from browsing on the leaves, but delivers it from the attacks of a much more dangerous animal—the leaf-cutting ant. For these services the ants are not only securely housed by the plant, but are provided with a bountiful supply of food, and to secure their attendance at the right time and place the food is so arranged and distributed as to effect that object with wonderful perfection."

Again he writes: "These ants seem at first sight to lead the happiest of existences. Protected by their stings they fear no foe. Habitations full of food are provided for them to commence housekeeping with, and cups of nectar and luscious fruits await them every day. But there is a reverse to the picture. In the dry season on the plains the Acacias cease to grow. No young leaves are produced, and the old glands do not secrete honey. Then want and hunger overtake the ants that have revelled in luxury all the wet season; many of the thorns are depopulated, and only a few ants live through the season of scarcity. As soon, however, as the first rains set in, the trees throw out numerous vigorous shoots, and the ants multiply again with astonishing rapidity."

I have quoted at length from the pages of Belt's "Naturalist in Nicaragua" because no words can better express the case for Acacia than these of the original discoverer. The nectar which the plant provides for its guests is formed in little cup-shaped glands situated upon the stalk to which the leaflets of the compound leaf are attached.

The food which the Acacia offers to its defenders consists of curious little pear-shaped, orange-yellow bodies —called Belt's bodies—which grow from the tips of the leaflets.

The researches of Francis Darwin* have shown that both the Belt's bodies of Acacia and the Müller's bodies of Cecropia are special modifications of ordinary leaf-glands, and it is certainly remarkable that two plants so widely separated from one another systematically should show such similar adaptations.

The most recent addition to the list of plants which afford board and lodgings to a defensive army of ants is *Macaranga triloba*, which has been studied by Miss Winifred Smith. This plant, which belongs to the Euphorbiaceæ, was found growing in the neighbourhood of Singapore. Its stems are hollow and divided into chambers by a series of diaphragms, which, however, become perforated. Ingress and egress into the cavity of the stem is afforded by little holes which are bored through the walls of the stem along a groove of thin tissue that extends above the point of leaf-insertion.

At the base of each leaf-stalk are a pair of curiously-shaped stipules which are pressed against the stem. Over the concave surface of these stipules are arranged a number of little, pear-shaped or spherical, golden-yellow food-bodies comparable with the Beltian or Müllerian corpuscles to which we have already referred.

The tips of the teeth along the margin of the leaf are converted into little cup-shaped glands which secrete nectar, no doubt for the benefit of the ant.

In the hollow stem Miss Smith found not only adult ants, but also pupæ and larvæ. These ants have been identified by Colonel Bingham as belonging to an apparently undescribed species of *Cremastogaster* near *C. daisyi* (Forel).†

Two very strange-looking plants from the Malay Archipelago—*Myrmecodia* and *Hydnophytum*—afford a home to certain ants, but do not provide them with food. These plants carry on an epiphytic existence upon tree trunks, and, as an adaptation to such a dry

* See Addendum at conclusion of this Article.

† In very cold periods the soldier ants are benumbed, and can no longer defend the tree against the leaf-cutters, which stand the cold much better, and are still active at comparatively low temperatures.

‡ For a fuller account of Cecropia, see especially (1) Fritz Müller's paper in Kosmos, Bd 8. 1880, and (2) Schimper's "Die Wechselbeziehungen Zwischer Pflanzen und Ameisen," Jena, 1888.

* F. Darwin, "Journal of Linnean Soc.," Vol. XV.

† For a full account of this case, see Miss Winifred Smith's paper "Macaranga Triloba; A New Myrmecophilous Plant," The New Phytologist, Vol. II., May, 1903, p. 79.

and airy situation, they have developed enormous tuberous water reservoirs.

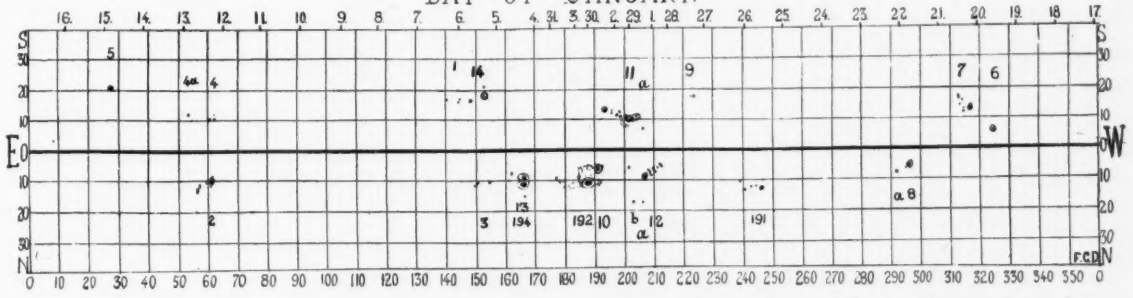
These water reservoirs are not solid throughout, but their interior is channelled in every direction with communicating passages. These passages are very probably connected with the aeration of the tissues of the tuber. Certain warlike red ants bore their way into these tubers and find the system of air passages a very comfortable home in which to live and bring up their young. A touch upon one of these plants thus inhabited will serve to bring forth an army of defenders ready to drive away the intruder.

Many other cases of what I have called "plant-hotels" have been studied, but, interesting as these all are, it would take too long to describe them. The cases which I have selected are, I think, representative, and will serve to illustrate the general features of these remarkable phenomena which are the common property of the two sciences of Botany and Entomology.

Since the above article was written papers have appeared from the pens of Ihering, Rettig, Ule, and Nieuwenhuis-Uexküll in which certain of Schimper's conclusions are questioned. It is impossible to discuss these papers here, but they show that the last word has not yet been said with regard to the relations existing between plants and ants.—R. B.

Solar Disturbances During January, 1909.

JANUARY has proved a very interesting month from the character of the disturbances rather than from their number. Surprise has been expressed in some journals at the continued activity, in view of the approaching minimum. This, however, is not due until the end of 1911 or the beginning of 1912. At noon on January 1st the longitude of the central meridian was 209° 38′.



Nos. 191, 192, and 194, from the last chart, remained visible during January, the first until 2nd, and the others until 9th.

No. 1.—On 6th one pore, two others 36,000 miles preceding it next day, last seen 9th, but area bright until 12th.

No. 2.—When first seen on 7th there were two spots, the larger leading. Two spots formed the rear 8th; the leader with three umbræ 14,000 miles in diameter on 9th, with a spotlet 58,000 miles behind; two pores east and one north 11th, with two umbræ. Solitary after until last seen on 18th. In area of No. 183.

No. 3.—On 8th three pores, 9th two, 33,000 miles apart, only facula after.

No. 4.—A tiny group of about three pores 9th, two seen 11th, and only one, greyish, 12th.

No. 4*a*.—A double pore, only seen 14th, whilst another one opened rather nearer equator for a little while on 15th, but its position was not determined.

No. 5.—Near the limb on 9th as a small spot; the umbra was bridged 12th; it shrank away, not being seen after 16th.

No. 6.—A spot which showed little change, during its apparition 14th to 25th, 16,000 miles in diameter.

No. 7.—A spot, with two small umbræ, 12,000 miles in diameter, 14th to 16th, a lozenge-shaped group of smaller spotlets 17th, a group of six pores with a leading larger spot 18th; the leader, with two spotlets south-east 20th and 21st, shrinking and alone, in a faculic area on 24th and 25th.

No. 8.—A spot south of the place of No. 190, seen 16th. On 17th a companion of large size following; the spot on 18th reached 22,000 miles in diameter, but had only two small pores eastward in a disturbed-looking area. Alone 20th and 21st. A spotlet, No. 8*a*, north-east on 22nd, and a smaller one 24th. Solitary 25th to 27th, but area following appeared very faculic.

No. 9.—A pore 22nd to 26th, a minute companion closely following on 25th.

No. 10.—A spot 16,000 miles in diameter, in area of No. 192, came round 22nd. A brilliant facula behind it 25th pointed to subsequent development. Three pores eastward 27th; by 29th a whorl of penumbral spotlets round south-eastern half. These gradually increased until on February 2nd the now diminished spot was surrounded by an ellipse of pores. Like two spots on 4th, last seen 5th.

No. 11.—Two spots 23rd, the preceding one 27,000 miles in diameter 24th. Pores showed between, and north of, spots 26th. A very brilliant area within the eastern spot on 27th. The leader had increased to 35,000 miles in length, with four umbræ, 29th and 30th, but was broken up by February 1st; seen until 3rd.

No. 11*a*.—A little group of pores just north of the western end of group. January 30th till February 2nd.

No. 12.—A very variable group of penumbra with numerous tiny umbræ. The continuous penumbra on 24th was 30,000 miles in diameter. On 30th a spot, 12,000 miles in diameter, with penumbral spotlets grouped towards south-west. Three small spots after, in faculic area, until February 2nd.

No. 12*a*.—A pair of pores separated by 22,000 miles, only seen 29th.

No. 12*b*.—A solitary pore following the group 29th till 31st.

No. 13.—A spot in thorough faculic connection with No. 10, 15,000 miles in diameter, apparently a return of No. 194, January 26th till February 7th.

No. 14.—A spot 14,000 miles in diameter seen January 26th till February 8th. A spotlet east by north 29th to 1st; a pore close south, 30th; and one west, February 4th and 5th.

The chart is constructed from the combined observations of Messrs. J. McHarg, A. A. Buss, A. Mee, and F. C. Dennett.

"Knowledge" Calendar for 200 Years

(From the Introduction of New Style).

By CHARLES E. BENHAM.

OCT.	MAY	FEB. AUG. NOV.	MAR.	JUNE	SEP. DEC.	JAN. APR. JULY	14
MAY	FEB. AUG. NOV.	MAR.	JUNE	SEP. DEC.	JAN. APR. JULY	OCT.	13
FEB. AUG. NOV.	MAR.	JUNE	SEP. DEC.	JAN. APR. JULY	OCT.	MAY	12
MAR.	JUNE	SEP DEC.	JAN. APR. JULY	OCT.	MAY	FEB. AUG. NOV.	11
JUNE	SEP. DEC.	JAN. APR. JULY	OCT.	MAY	FEB. AUG. NOV.	MAR.	10
SEP. DEC.	JAN. APR. JULY	OCT.	MAY	FEB. AUG. NOV.	MAR.	JUNE	9
JAN. APR. JULY	OCT.	MAY	FEB. AUG. NOV.	MAR.	JUNE	SEP. DEC.	8
MAY	AUG.	FEB. MAR. NOV.	JUNE	SEP. DEC.	APR. JULY	JAN. OCT.	7
AUG.	FEB. MAR. NOV.	JUNE	SEP. DEC.	APR. JULY	JAN. OCT.	MAY	6
FEB. MAR. NOV.	JUNE	SEP. DEC.	APR. JULY	JAN. OCT.	MAY	AUG.	5
JUNE	SEP. DEC.	APR. JULY	JAN. OCT.	MAY	AUG.	FEB. MAR. NOV.	4
SEP. DEC.	APR. JULY	JAN. OCT.	MAY	AUG.	FEB. MAR. NOV.	JUNE	3
APR. JULY	JAN. OCT.	MAY	AUG.	FEB. MAR. NOV.	JUNE	SEP. DEC.	2
JAN. OCT.	MAY	AUG.	FEB. MAR. NOV.	JUNE	SEP. D	APR. JULY	1

SUN.	M.	T.	W.	THU.	F.	SAT.	1	8	15	22	29
M.	T.	W.	THU.	F.	SAT.	SUN.	2	9	16	23	30
T.	W.	THU.	F.	SAT.	SUN.	M.	3	10	17	24	31
W.	THU.	F.	SAT.	SUN.	M.	T.	4	11	18	25	
THU.	F.	SAT.	SUN.	M.	T.	W.	5	12	19	26	
F.	SAT.	SUN.	M.	T.	W.	THU.	6	13	20	27	
SAT.	SUN.	M.	T.	W.	THU.	F.	7	14	21	28	

1753 2	1754 3	1755 4	1756* 12	1757 7	1758 1	1759 2	1760* 10
1761 5	1762 6	1763 7	1764* 8	1765 3	1766 4	1767 5	1768* 13
1769 1	1770 2	1771 3	1772* 11	1773 6	1774 7	1775 1	1776* 9
1777 4	1778 5	1779 6	1780* 14	1781 2	1782 3	1783 4	1784* 12
1785 7	1786 1	1787 2	1788* 10	1789 5	1790 6	1791 7	1792* 8
1793 3	1794 4	1795 5	1796* 13	1797 1	1798 2	1799 3	1800 4
1801 5	1802 6	1803 7	1804* 8	1805 3	1806 4	1807 5	1808* 13
1809 1	1810 2	1811 3	1812* 11	1813 6	1814 7	1815 1	1816* 9
1817 4	1818 5	1819 6	1820* 14	1821 2	1822 3	1823 4	1824* 12
1825 7	1826 1	1827 2	1828* 10	1829 5	1830 6	1831 7	1832* 8
1833 3	1834 4	1835 5	1836* 13	1837 1	1838 2	1839 3	1840* 11
1841 6	1842 7	1843 1	1844* 9	1845 4	1846 5	1847 6	1848* 14
1849 2	1850 3	1851 4	1852* 12	1853 7	1854 1	1855 2	1856* 10
1857 5	1858 6	1859 7	1860* 8	1861 3	1862 4	1863 5	1864* 13
1865 1	1866 2	1867 3	1868* 11	1869 6	1870 7	1871 1	1872* 9
1873 4	1874 5	1875 6	1876* 14	1877 2	1878 3	1879 4	1880* 12
1881 7	1882 1	1883 2	1884* 10	1885 5	1886 6	1887 7	1888* 8
1889 3	1890 4	1891 5	1892* 13	1893 1	1894 2	1895 3	1896* 11
1897 6	1898 7	1899 1	1900 2	1901 3	1902 4	1903 5	1904* 13
1905 1	1906 2	1907 3	1908* 11	1909 6	1910 7	1911 1	1912* 9
1913 4	1914 5	1915 6	1916* 14	1917 2	1918 3	1919 4	1920* 12
1921 7	1922 1	1923 2	1924* 10	1925 5	1926 6	1927 7	1928* 8
1929 3	1930 4	1931 5	1932* 13	1933 1	1934 2	1935 3	1936* 11
1937 6	1938 7	1939 1	1940* 9	1941 4	1942 5	1943 6	1944* 14
1945 2	1946 3	1947 4	1948* 12	1949 7	1950 1	1951 2	1952* 10

* Leap Year.

CALENDAR—1753 to 1952.

Under the year find its number. Take the month row in line with that number as the heading of the Week-table below. The week-day for any date in that year will be found in line with the figure representing the day of the month.

Ex.: 1877 (2) June 24 = Sun.
Aug. 21 = Tues.

1844 (9) May 31 = Fri.
Feb. 29 = Thurs.

Photography: Pure and Applied.

By CHAPMAN JONES, F.I.C., F.C.S., &c.

The "Omnicolore" Screen Colour Plate.

This colour plate is now to be bought on the Continent and will doubtless soon be obtainable in this country. Like all other screen colour plates, it is in principle analogous to the autochrome plate and is used in a similar manner, but differs from it in the character and method of manufacture of the colour screen upon which the sensitive emulsion is laid. MM. L. Ducros du Hauron and R. de Bercegol are the inventors of the plate, and it is made in the factory of MM. Jougla and Co. It is stated that the three colours are put upon the plate by first coating it with gelatine, printing upon the gelatine sufficiently fine and close parallel lines in a greasy ink of one colour, impressing another series of lines at right angles to the first in a greasy ink of the second colour, "dodging," so that the superposition of the two series of lines where they cross is prevented, and, finally, putting the plate in an aqueous solution of the third dye that the small rectangular spaces of the gelatine film not covered by either of the series of lines may absorb the colour and leave no white spaces. The plates as now made may be described as having continuous blue lines with spaces between rather wider than the lines, these spaces being filled with lines made up of alternate rectangles of red and green. They, therefore, recall the method of colour distribution in the Joly and MacDonough plates in which the three colours alternated in continuous lines, but with the advantage that two lines are merged into alternating patches. The Thames plate, it will be remembered, goes a stage further in eliminating the line element, using two series of round dots and filling in the interstices with the third colour. Whether the one continuous line of the Ommicolore plate gives a disagreeable effect or not remains to be seen; it is, perhaps, unfortunate that it is in the darkest of the three colours. Although it is stated that these plates give excellent reproductions of colour, the reports of those who have examined them analytically are not very satisfactory. We are told that the screens have flaws in them, that there are white spaces between the colours, that the colours are not laid on evenly, that the colours of the dyes are not well selected, and that the emulsion is slow. But it must be borne in mind that the manufacture of these polychromatic screen plates is in its infancy, and will, without doubt, improve as experience is obtained and the workmen become accustomed to the new industry. Messrs. Lumière, by years of work, brought their autochrome plate to a wonderful degree of perfection before putting it on the market, but even they have varied and improved it since its introduction.

"Ensyna" Paper.

By the courtesy of Messrs. Houghtons I have been able to make further experiments with this remarkable paper. The sensitive salt is silver phosphate, and the development is of the kind known as "physical," that is, silver is deposited upon the image produced by light. There is no silver in the developer as prepared for use, but the sensitive film is acid and the developer is acid, and as silver phosphate is soluble in acids, when the developer is poured on the paper the silver salt in the film is gradually taken up by the solution and provides the silver that is deposited upon the image. Thus the silver available for development is introduced into the developer with a regularity that would be quite impossible if it were added to the developer in small doses of a separate solution, as is the general custom in cases of physical development, as, for example, in developing wet collodion plates. This automatic regulation of the introduction of the silver into the solution ensures a gradual development whatever the exposure. By increasing the exposure the resulting image becomes more red and with diminishing contrast. The image may be printed out, but if fixed straight away it will lose the greater proportion of its density. After printing out, a short development in a diluted developer will give an image that will change little, if at all, in the fixing bath. Such an image is a very reddish shade of brown and flat, unless the negative is unduly hard; but, of course, the paper is not intended for such treatment. The makers say that "the tone is entirely governed by the exposure and not by the development." This appears to be true if development is always carried to the same degree of image density, as one would endeavour to do in making many duplicates. But this paper appears to be no exception to the rule that the more of the work that is done by the exposure and the less by the development the redder the image. With sufficient exposure the image on development begins red and gradually passes through sepia to a blue black, but only one tint will correspond to the most suitable amount of development. With the same exposure, development may be stopped at the reddish brown, sepia, purple, or black stage, and if these latter over-developed prints are reduced by dissolving away a part of the image, they retain their colour, and in this way differently coloured images are obtainable with the same exposure; but obviously such prints will not all have the same scale of gradation. With under exposure only the black or colder tints are obtainable, with a tendency to excessive contrast. Increased exposure, as usual, tends to flatness of image. It is of interest to note that there appears to be no sign of reversal within an enormous range of light action, exposure and development being interchangeable, with the limitations as to colour, gradation, and density, and the difference in constitution between the merely printed-out and the developed image, noted above. I have exposed some of the paper under clear glass to daylight for periods up to about two days, during a part of which time the sun shone directly upon it. After a certain exposure, when an almost black colour is obtained, further exposure seems to be without effect. This colour loses nothing on fixing, nor does it change materially when treated with the developer supplied for the paper. It will, of course, be understood that such treatment as is here described is not suitable for the getting of ordinary prints. For this purpose a very few seconds' exposure and development as directed cannot be improved upon.

A Lantern Plate.

Messrs. Wratten and Wainwright have just issued a new lantern plate prepared without chloride of silver. It gives a good black image with a minimum exposure and suitable developer, and a warmer image with more exposure and restrained development. The developers recommended are very strong, but I find that an ordinary pyro. ammonia developer gives a pleasant warm colour. The plates are of excellent quality, give very clean results, and will stand almost any treatment without going wrong. Indeed, the makers recommend the addition of a considerable proportion of a 10 per cent. solution of hypo. to the developer for getting reddish images.

XUM

Notes on Some Striated Gravels in West Kent.

By J. RUSSELL LARKBY.

THERE is an increasing circle of geologists, especially in the younger school, who now fearlessly accept that which their forbears thought to lie beyond the bounds of demonstrable possibility. In no department of geology is the forward tendency so markedly shown as in the acceptance of evidence addressed in support of the "greater antiquity of man." The question of this antiquity has never failed to arouse enthusiasm, and a synopsis of the various stages in the progress of man's knowledge of the antiquity of his race would in itself present a story of much interest.

At the present day the younger geologists view with incredulity the apparently unnecessary caution in the long-delayed acceptance of the authenticity of Palæolithic man. It seems impossible, now the curtain has been partially drawn from the past, that those magnificent Palæoliths from France and Southern England were made to stand on trial before a scientific tribunal and undergo the slow process of sceptical discussion. The existence of Palæolithic man is now as faithfully received as the most patent fact in history. To the ambitious geological mind of the present day, however, the considerable antiquity assignable to Palæolithic implements offers no limit to the antiquity of the race, for a widely received opinion is that the "extreme rudeness of a chipped flint is not in itself a ground for its rejection as the work of man."* Indeed, the probable existence of a type of implement earlier than the accepted Palæoliths was recognised many years before the disputed Eoliths appeared to enlarge our views on the antiquity of man.† To a consideration of some of the evidence for one aspect of this pre-Palæolithic stage of man's progress, attention is now invited.

It is a matter of common knowledge that the Palæolithic forms are found either in direct connection with streams still running, or in gravels traceable to the former and higher action of those agents. It should also be a matter of common knowledge—and this is a most important factor in the case for antiquity—that the higher the level on which search is made, the older is likely to be the evidence produced. This, of course, is only true on the assumption that the elevation of the gravel is not due to an uplift subsequent to its deposition. This may be tested by a careful examination of a set of plans showing the country by which it is proposed to illustrate the sequence of the various gravels. In areas where fluviatile denudation has gone on for any length of time, the levels of the land will rise to a certain general height above sea-level and these summits will represent the once continuous but now eroded plain on which the rivers worked in their earliest phases.‡ From a theoretical standpoint, then, it appears that at last a high level gravel should be reached from which the most careful scrutiny fails to produce any evidence of man; but here theory is not quite in line with practice, for from the majority of high-lying fluviatile gravels south of the Thames observers have found flints bearing more or less evident signs of artificial chipping.

To show the general occurrence of these disputed forms in high gravels on the northern outskirts of the Weald, it may be well to quote a few gravels from which such evidence has been obtained:—

(1) *Terry's Lodge*, at 760 feet O.D., crowning the chalk escarpment north of Ightham.

(2) *Well Hill, Shoreham*, at 610 feet O.D., an eminence almost completely isolated from neighbouring watercourses.

(3) *Newlands Corner*, 2½ miles east of Guildford, at 570-600 feet O.D., and crowning the chalk escarpment there.

(4) *Hungry, or Hungary, Hill*, 1½ miles north of Farnham, at 600 feet O.D.

It is unnecessary to further expand the list, as the reader can supplement it from his own observations.

There are two points in which these gravels agree:—

(1) The presence of southern drift materials, showing the depositing agents to have headed in an elevated southern region, *i.e.*, before the development of the east and west vales of the Weald.

(2) The apparent absence of implements of distinctly Palæolithic type.

With the possible exception of the Terry's Lodge deposit there is another important agreement in the absence of striated materials. Incidentally it may be mentioned that the Well Hill gravel bears a remarkable resemblance to the deposit at Hungry Hill. The Well Hill section is too small to show distinct and continuous stratification, but it is interesting to note that up to about 1870 brick earth was extracted from one portion of the ridge. From enquiries made in the locality it appears that the gravel and brick earth occurred in alternate deposits. In this particular the gravel closely resembles the Newlands Corner deposit, for during a visit to that section in July, 1905, a very distinct stratification was exhibited. Intercalated in the gravel were small deposits of sandy and indurated brick earth showing current bedding.

Into the vexed question of the age of these high gravels it is not proposed to enter, but up to the present time Prestwich's claim that the Well Hill gravels, at least, are pre-glacial stands in the field.*

It is clear from geological reasons that since the deposition of these plateau gravels enormous erosion has taken place which, if not representative of a long period of time, must, on the other hand, be indicative of very considerable power in the eroding agents. The possibility of glacial conditions of a modified type being partially accountable for this great denudation, or, at least, the effect of a far more rigorous climate than the present, may help us to a more truthful reading of the processes of surface development. The general absence of drift in the higher stages of the Homesdale and Darent Valley may suggest that some agent has been in operation which not only actively denuded the land, but also carried away a large proportion of the results of such erosion; but whether this is due to rivers acting under frozen conditions, and by means of river ice, transporting the materials thus worn from the land, does not at present admit of any definite answer, for it may be objected that the absence of drift is due to the weathering and widening of the valleys with a resultant disappearance of the old terraces once existing therein. Against this it may be remarked that, although we have distinct evidence of the wasting back of the chalk

* "A Guide to the Antiquities of the Stone Age in the Department of British and Mediæval Antiquity," C. H. Read, p. 11.

† "Ancient Stone Implements of Great Britain" Sir John Evans, 1st Ed., 1872, p. 425.

‡ "Britain and the British Seas," H. J. Mackinder, p. 108.

* "On a Southern Drift in the Thames Valley and its Relation to the Westleton Beds, etc." Professor J. Prestwich, Q.J.G.S., May, 1890, p. 179, Act 13 of General Summary,

escarpment in the accumulation of highly weathered chalk at the base of the slopes, there is no evidence of any re-arranged drift from the suggested terraces once existing higher up the slopes. For this accumulation of weathered chalk Mr. F. J. Bennett, F.G.S., has proposed the name of scarp drift. It is only possible to note the general absence of those deposits abounding in places where admittedly post-glacial erosion has taken place. Whatever view is taken of the eroding agents in the earlier phases of the Homesdale and Darent Valley this much is clear, that on the high land fringing the northern slope of the former feature a definite gravel occurs, and if evidence is wanted that its deposition vastly ante-dates the erosion of the valley below, it is forthcoming in the various breaches in the northern escarpment of the chalk made by the Stour, Medway, Darent, Mole, and Wey. If, therefore, the Homesdale is regarded as being partially due to erosion in glacial times,* then it seems highly probable that a drift demonstrably older than, and having no direct relation to, that valley may belong to a period antedating the deposition of some of the glacial deposits to the north or, at least, forming the time equivalent to them. Under any circumstances it is necessary to clear away any prejudice as to the impossibility of man's location in the south-east of England at a time when glacial action was still in progress in other parts of the country. It is generally agreed that, although the southern parts of England were not involved in the active "glaciation," yet they did not altogether escape the southerly and concurrent effects of that period of greater cold. On this point Professor James Geikie remarks that the observer should be prepared to meet with evidence of greater fluviatile action in regions lying outside the glaciated areas.† But we may perhaps, go further than this and suggest the occurrence of evidence indicative of a modified ice action. As stated above, the plateau gravels crowning the chalk escarpment are certainly of great age, for since their deposition the drainage of the Weald has undergone great modification. On the other hand, no difficulty can be raised in concluding the valley gravels to be post-glacial. It is possible, therefore, that if the south-eastern part of England has undergone a mild and intermittent glacial erosion, some evidence of that action may occur on an intermediate level between certain post-glacial and, perhaps, pre-glacial gravels; but in dealing with these intermediate gravels it is unnecessary to postulate glacial conditions in the Continental sense of the term—a more probable condition would be the existence of river ice. In assigning these deposits to river ice the action of water is, of course, necessarily included; the flints were washed from the chalk most probably by the scour of the stream in times of flood consequent on heavy rains, but the generally unabraded condition of the constituents requires the action of some agent capable of transport unattended by rolling. Small landslips due to the undermining of banks on the outer sides of curves, or the creep of partially frozen earth, would precipitate material into the water.

To test this proposition attention may now be called to the probable action of river ice as an agent in the deposition of certain high gravels within the former radius of the Darent.

Some 2¼ miles north of the Darent gap in the chalk escarpment is the high Tertiary outlier of Well Hill, capped by a gravel agreeing in almost all respects to deposits at Newlands Corner, near Guildford, and Hungry Hill, near Farnham. Very careful and frequently repeated examinations of this deposit have failed to produce a single striated stone, and this, considered in conjunction with the general features of the local geology, warrants its relegation to a very early age, regarded, indeed, by Presturia as the time equivalent of the Reg Crag.† A reference to the section will show the elevation of the deposit, and the great denudation of the surrounding country subsequent to its deposition. At a lower level, on a small plateau varying from 420-450 feet O.D., and having a general slope to the north, owing to the dip of the underlying deposits as well as to fluviatile action, is a gravel of varied composition containing a large number of striated flints, some of which bear definite evidence of man's handiwork. Below this gravel, and at an elevation of only 187 feet O.D., is the present course of the Darent, where the striated gravels are again non-existent. Thus we have along the line of the section three spreads of gravel with an extreme difference of level amounting to 423 feet. There can be little difficulty in accepting the low level gravel as a post-glacial deposit, as it contains not only well-worked Palæolithic implements, but also remains of Elephas Priniquins so often associated with valley deposits. The important point connected with these gravels, assuming them to be all Darent deposits, is that we have evidences for the erosion of Tertiaries amounting to 130 feet, and of chalk to the extent of 293 feet. The amount of time required for this erosion must have been enormous, and, in addition, the period must be still further protracted as the channel was deflected as well as deepened. As the gravel resting at 450 feet is placed between high and low level unstriated drifts its significance becomes prominent, and some explanation is necessary to meet the peculiarity. The chief characteristics of the striated flint may be summed up as follows:—

(1) The striæ are short, rarely exceeding an inch in length.

(2) They cross each other at all angles.

(3) They are more pronounced on the flatter portions of the flints, and fainter in the hollows.

(4) The more pronounced surface ridges are distinctly reduced in their asperities.

(5) The flints on which the striæ occur are not usually rolled, although slight wear is seen on the more prominent angles. A few show insipient cones of percussion caused by the impact of one flint on the surface of another. This may be regarded as evidence that at times the flints were under ordinary fluviatile action.

(6) Green-coated flints from the base of the Thanet Sand are, owing to their softer nature, frequently striated in a more definite manner. On

* "A Guide to the Antiquities of the Stone Age," C. H. Read, p. 26.

† "Fragments of Earth Lore," p. 176.

‡ "Twelve Years of London Geology," W. Whitaker, F.R.S., Presidential Address to the Geologists' Association, 1901.
"On the New Railway Cutting at Guildford," Lt.-Col. Godwin Austin, *Geological Magazine*, 1884.
"On Some Sections between West Thurrock and Stifford," T. F. Holmes.
"Notes on the High Level River Drift between Hanwell and Iver," J. Allen Brown.
"Reports West Kent Natural History Society," F. J. C. Spurrell, 1886.

* For a summary of the implements occurring in this area, see "Notes on Prehistoric Man in West Kent," J. Russell Larkly, *Antiquary*, March and April, 1905.

† See also "Superficial Deposits of Central and Southern England," A. E. Salter, F.G.S., *Proceedings* of Geologists' Association, Vol. XIX., Part I., 1905.

other flints not having green coatings, but where the surface has been much corroded, the striæ are again well developed.

(7) In many cases the striæ pass under the patches of staining due to oxide of iron; from this it is clear that to whatever cause the staining is due it is later than the imposition of the striæ. It has been asserted, though definite proof is not forthcoming, that the patchy staining seen on the surface of flints is due to contact with agricultural implements; its unequal distribution over certain areas militates against this theory and a more probable solution is to be found in suggesting a ferruginous constituent in the soil, for in some cases small specks of iron oxide can be seen adhering to the surface and forming a nucleus to a small circular stain. In some cases the patches of staining are also striated, and from this it seems that little importance can be attached to the presence of the partial discoloration as a guide to antiquity. The phenomenon of staining is an accidental one due to the wearing away of ferruginous rocks. It is true that the older implements are usually stained, a circumstance due to the fact that during the deposition of their containing gravels the rivers were working on Tertiary deposits which contain a greater proportion of iron than the chalk.

Before attempting to show the striæ as being due to river ice, it may be well to review two suggested explanations each avoiding that agent :—

(1) That they are due to the acids in rootlets which have attacked and dissolved that part of the flint with which it comes into contact.

(2) That they are due to some slight difference in the structure of the flints, and that the lines represent the former positions of that softer material since weathered out.

These suggestions are greatly negatived by the general occurrence of the striated flints at or about the 430-470 levels in the area now under review. If they are due to such natural causes, then it is reasonable to suppose that they should occur at all levels, which certainly is not the case. In the first explanation, too, it is obvious that the older the gravel the greater should be the striation, because on this theory it has been exposed for a longer period to the supposed rootlet action; but here, again, no confirmatory evidence is obtainable, for, generally speaking, the high level gravels, *i.e.*, those lying above 430 feet O.D., show no striated materials or any feature distinctly indicative of ice action (Well Hill, Newlands Corner, and Hungry Hill). I very much doubt if the acids of rootlets is of sufficient strength to impose the markings. It is true that rootlets possess the power of eating into slabs of marble—indeed, this is a usual botanical experiment to illustrate the chemical properties of rootlets, but between these indistinct markings and the definite grooves on the striated flints no comparison can be made. On the other hand, these striæ are explicable on the theory of river ice. The fact that the striæ are short, rarely exceeding an inch in length, and that they frequently cross each other at all angles, show that the stones frequently came into short but powerful contact with each other under constant change of direction and frequent movement in position as they were frozen in and melted out on their journey towards the debouchure of the river. Indeed, it is not difficult to outline the probable condition of things during the deposition of this gravel. At that time the lowest level of the area was somewhere between 400-450 feet above the sea, and the present deep gorge of the Darent merely in an incipient stage. Instead of the now practically waterless Homesdale, the Darent probably flowed in considerable volume through the Darent gap from the neighbourhood of Ightham, over what is now the Darent Shode divide, for along the Homesdale and on the Cockerhurst flood plain occur rolled fragments of Oldbury stone pointing to the earlier direction of the Darent.* At the approach of summer the snow and ice of the higher lands in the catchment basin would melt and flood the river, whilst portions of the frozen material would float away in the accelerated current. In these small ice rafts there might well be materials derived from the waste of the land, and to these would be added stones and earth worn from the banks as the floes stranded in shallow water on the inner sides of curves. It is not unlikely that to the erosive work of these periodical floodings we owe the trumpet mouth of the Darent, which is apparently a simple notch very much widened by the scour of the stream as it left the east to west Homesdale and turned north towards the Thames. Granting, then, that this trumpet mouth was originally little more than a notch in the growing and receding chalk escarpment, it is very probable that at times, before it reached its present dimensions, it was under favourable circumstances blocked by the accumulation of partially frozen material.† The bursting of any temporary barrier at the mouth of the gorge would give a greatly increased impetus to the water by which the ice floes would be carried with considerable force to a slightly higher level than under normal conditions; they would thus tend to become stranded in shallows or backwaters, and although the individual portions of ice might have been of insignificant proportions, yet the accumulation of masses would result in considerable pressure on the underlying parts. In this accumulation it is not unlikely that we have the explanation of the striæ. If the angular flints carried in one ice floe were forced over those contained in another striation of a kind would ensue. In addition to this, however, the pressure of silt partially or wholly frozen must be taken into account, for at this place the soil is largely made up of small angular and sub-angular grains of quartz. I find that by applying a flint with considerable pressure to a piece of emery cloth, slight striation results. Incidentally it may be mentioned that it is also possible to scratch the surface of one flint with the point of another, although, owing to the comparatively slight pressure obtained by hand power alone the marks so imposed are necessarily feeble.

There is a tendency to regard these striæ as being due to the creep of frozen soil, and Mr. S. Hazzeldine Warren, in a very able paper read before the Anthropological Institute on December 19, 1905, repudiating the authenticity of Eoliths, referred the striæ to this type of action. He also referred certain Eolithic forms to this purely natural agent. Whilst not agreeing with

* In this connection it may be pointed out that Oldbury Stone has not been found in the Homesdale east of the Shode Gap in the Lower Greensand Escarpment. This I have on Harrison's authority, who many years before my time found rolled fragments of that rock in the Homesdale west of the Shode, and at Cockerhurst. There are masses of Oldbury Stone a short distance south of Yaldham Manor, 2¼ miles north of the outcrop of Oldbury Stone.

† A somewhat similar occurrence may have taken place south of Guildford, where the Wey breaches the Chalk and Greensand escarpments. The ponding back of material here is suggested by the wide spreads of gravel at Peasmarsh and Shalford Common; this gravel, however, is of a much later date than the deposit now under review.

the latter proposition, it is impossible to refuse a partial support to the former, but this does not in any way detract from the significance or importance of the striæ as showing man's co-existence with a modified type of glacial conditions, for a climate sufficiently severe to produce a frozen soil would also be sufficiently severe to produce that type of fluvio-glacial action to which I refer the striæ. It is, perhaps, wiser to suggest the existence of both actions as co-agents in the productions of the scratches.

The greater development of the striæ on the flatter surfaces and their decrease in the hollows is to be expected in both types of action, and the reduction of the surface ridges is obviously explicable on this theory, since those asperities would be more open to attack than other parts. There can be little doubt as to the capability of river ice to pick up and transport flints, for in the Report of the Thames Commission Appendix I., 1866, the Rev. J. C. Clutterbuck places on record that he has seen "pieces of rock, eight pounds in weight, raised by a mass (of ice) from the bottom and carried down the river. *

The largest block of striated material yet found in the striated gravels of either the Cray or Darent is a pear-shaped mass $8'' \times 5'' \times 3\frac{1}{4}''$ weighing $4\frac{1}{4}$ lbs.; its edges are slightly abraded by rolling, and the flatter surfaces are profusely striated with but few insipient cones of percussion due to free rolling in a moving body of water.

The coincidence in the level of these striated gravels is all important; they occur at Cockerhurst and Well Hill at levels varying from 430-450 feet O.D.; in a gravel marking an initial stage of the Cray at 440 feet O.D.; and at Farnham in the highest terrace of the Wey, some distance above the 300 feet contour. In the latter gravel they are associated with well-worked Palæolithic implements. This association of type, however, offers no difficulty, for the few striated implements in the Farnham gravels are highly rolled and probably came from an earlier gravel broken up by erosion and redeposited during Palæolithic times. On the striated gravels of the Cray and Darent finely worked Palæoliths also occur, but as they show neither abrasion or striation, and do not agree in mineral condition with the deposit on which they occur, they seem to be sporadic specimens, although in the case of the Cray they may indicate a site inhabited during Palæolithic times.

When I brought my observations and implements before Mr. C. H. Read, of the British Museum, objection was made, and rightly so, that as the flints were surface finds, no definite argument could be adduced from them. During November of 1904 I took advantage of permission accorded by Sir William Hart-Dyke to sink a section at Cockerhurst Farm on the flood plain shown in the section; this resulted in the exposure of the deposit hereunder noted.

The conclusion to be drawn from this section is that when the Darent—and to a lesser degree the Cray also—had cut its channel to immediately below the 430-450 lines, they were depositing striated materials. As before noted, this gravel is placed between high and low level deposits where striated stones are not known to occur. The balance of probability seems to point to the suggestion that during the deposition of this striated gravel climatic conditions of some severity obtained in this area, but whether they represent the southern equivalent of that greater cold evidenced by the deposits found north of the Thames does not, at present, admit of definite answer. Whatever may be the true explanation of these striæ, there can be little doubt that they are later than the period of chipping. Against the human origin of the chipping no great objection has been raised, and if my interpretation of these striæ is correct then, locally, there is evidence that man may be considered as pre-glacial.

Throughout this paper the term "glacial" as applied to gravels has been used without any intention of marking off a definite period. The term has been used in a strictly local sense as evidence of a colder climate than the present.

* Quoted by Huxley, "Physiography," p. 154, 1st Edition. See also 2nd Edition, edited by Professor Gregory.

Cardiography.

By C. E. LEA, M.B.

IN no department of medical science, perhaps, have the latest scientific appliances been more practically utilised than in that branch which deals with the graphic method of recording the heart's movements in man.

Up to a few years ago our knowledge of the heart mechanism in health and disease was practically limited to what could be made out by listening over the heart area with a stethoscope and by inferences somewhat arbitrarily drawn from the character of the pulse. But whilst not wishing to detract in any way from the skill and acute observations of the older physicians with these limited methods of observation at their disposal, at the present day there is no doubt that instrumental assistance, such as I am about to briefly describe, is essential for an accurate picture of the cardiac condition.

The history of this great advance in our knowledge began when a little instrument (Fig. 1), the sphygmograph, was invented. It is an instrument for graphically recording the pulse. It is fastened by a band around the wrist. A small knob is adjusted over the beating radial artery, so that each pulsation jerks the knob gently upwards. These pulsations are magnified by a delicate system of levers connected on the one hand with this little knob, and on the other with a recording stencil which at each pulsation is jerked across a moving surface, a piece of smoked glazed paper.

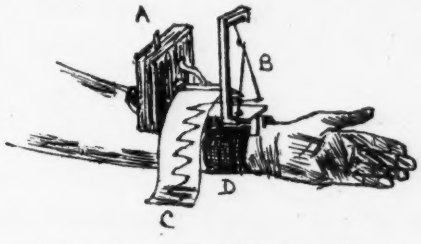


Fig. 1.—Sphygmograph Pulse Recording.
A—Clockwork apparatus. B—Lever system connected to recording needle. C—Moving Glazed paper. D—Wrist band.

The result is a tracing something like this :—

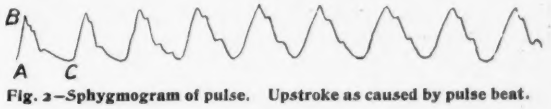


Fig. 2—Sphygmogram of pulse. Upstroke as caused by pulse beat.

Here every up-stroke, AB, is caused by the needle being jerked across the paper by the beat of the pulse. The down-stroke, usually wavy, BC, is caused by the

needle returning back across the paper for the pause before the next beat.

Sometimes the pulse beats are not so regular in size and in the time between the sucessive beats. Then we get a tracing like this :—

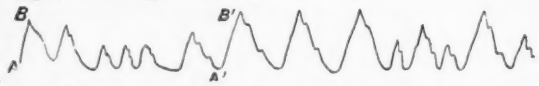


Fig. 3.—Sphygmogram of pulse. Irregular in strength of beat and rhythm.

Here the beats AB, A^1 B^1 are of different strengths. Some are big beats; others are very small. And the distance between successive beats is very variable. This is a form of *irregular* pulse, and shows that the heart is not beating regularly.

If a heart is beating quickly the tracing looks like this :—

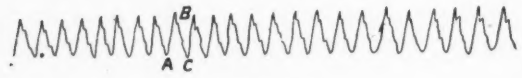


Fig. 4.—Rapid pulse.

If a heart is beating slowly the tracing looks like this :—

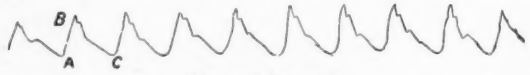


Fig. 5.—Slow pulse.

As the heart is resting after each beat (marked AB on the tracing) from B^{-C} the slower the heart beats the longer will this distance BC be, and the longer time will the heart have to rest before its next beat. So that when a person has fever and the heart is beating 120 to the minute instead of 70, this rest period BC is shortened, the heart has less time to recuperate after each beat, and this is why the heart becomes temporarily weakened, and the patient feels exhausted.

Sometimes it happens that the heart beats in couples like this :—

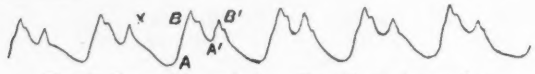


Fig. 6.—Form of irregularity. Heart beats in couples.

Here two beats come close together and then the heart gives a long pause after such an unusual effort, and then fires off another two, and so on. The first beat, AB, is a strong one, because the heart has had a long rest from X-A. But A^1 B^1 is much smaller. That is because the heart has had such a short rest, B-A^1, that it has not properly recovered to give a normal beat.

Until the sphygmograph was invented such a pulse would be wrongly interpreted. For only the big beats, AB, could be felt by the finger at the wrist, and the little one would not be strong enough to be felt. And so the rate of the pulse would be counted at only half of what it really was.

Here is a pulse tracing where every other beat of the heart is smaller than it ought to be, but the rhythm is regular :—

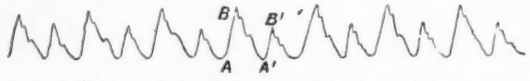


Fig. 7.—Form of irregularity. Every alternate beat smaller than normal.

The difference in size of the beats here, however, is too small to be detectable by the finger placed over the pulse at the wrist. This variety of pulse, then, would be missed without the aid of the sphygmograph. Indeed, this type was unknown until this instrument was invented. But it is a very important clinical sign, because it means that the heart muscle is deficient in its muscular function of contractility. For a similar reason the "pulsus bigeminus" (Fig. 6) could not be detectable at the wrist. This coupling of beats frequently occurs over long periods of time. The patient himself may not be aware of it. It causes no symptoms. Napoleon is said to have had a phenomenally slow pulse. It was only 40 to the minute, instead of normally 70 or 80. Can it be that really his pulse was a normal 80, but that every other beat was missed at the wrist, and so it was thought to be only 40?

Innumerable other forms of arhythmia could be described. These are but a few examples. Obviously only by this graphic method of studying irregularities by comparing, contrasting, and classifying, could any advance in cardiac pathology be made. But clinicians did not rest satisfied with the sphygmograph. The pulse at the wrist only tells us what is being done by the ventricles of the heart, the muscular, contractile portions of this organ. It tells us nothing of what is occurring in the more delicate but equally essential part of the heart, the auricles. It was the aim, then, of clinicians, to discover how the movements of the auricles could be recorded as well, but before entering this second phase of discovery we must briefly contrast these two anatomical divisions of the heart.

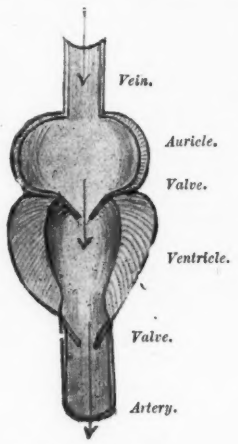


Diagram of the Heart.

As is generally known, the heart is a hollow, muscular organ, divided into four chambers, two auricles, and two ventricles, into which the blood from the veins enter and out of which the blood is projected into the arteries by the alternate contraction and relaxation of these chambers. By each contraction of the ventricles a fresh quantity of blood is projected into the elastic-walled arterial system, and it is this ventricular contraction that is felt at the wrist as the pulse. Before the blood from the veins reaches the ventricles of the heart, it is delayed for a short time in the other portion of the heart, the auricular chambers. These chambers, as shown in the diagram, adjoin the ventricles, but valves intervene between the respective auricular and ventricular cavities, so that the blood can pass through the heart in only one direction, namely, from auricle to ventricle. The ventricles are the working, pumping

portion. Their walls are thick and muscular, unlike the auricles which, though they, too, contain some muscular fibres, are thin-walled and relatively weak.

It is the ventricular contraction alone which makes itself felt at the pulse. The auricles, which receive the blood first from the veins, contract a fraction of a second before the ventricles, and, by doing so, force their contents through the valves into the ventricles, but their action is too feeble to be recorded at the wrist. By these chambers contracting upon the ventricle, the blood is ensured of passing in only one direction, namely, vein to auricle, auricle to ventricle, ventricle to artery; aided, of course, by the arrangement of the valves which permit the blood to pass in only one direction.

Now, whilst apparently the auricles, these ante-chambers to the ventricles, have little to do with forcibly "making the blood go round," doing nothing more than receive the blood from the veins, keep it waiting till its hard-working neighbours, the ventricles, have finished despatching the last quantity of blood into the arteries, and then, by a little squeeze of their own, forcing the waiting blood into the receptive ventricles, they constitute, in reality, the vital portion of the heart.

Though the auricular contractions are so feeble when compared to the ventricular that no record of their movements can be seen on the radial sphygmogram, the vital importance of the auricles lies in the fact that they set the speed at which the heart must beat. *They initiate the rhythm.* The ventricles mechanically follow the auricles. If the ventricles are the muscular forces of the heart, the thin-walled, highly strung auricles constitute the brain of this organ.

Whatever rate at which the auricles are induced by various causes to beat, the ventricles follow. This normal sequence can readily be seen in the exposed beating heart of a dog, for example, where the auricles can be distinctly seen beating before the ventricles. Since the Röntgen rays have been introduced it is possible now, by means of the fluorescent screen, to watch the heart beating in the living human subject, and this same phenomenon is visible.

It has been stated that the pulse tracings only indicate what the ventricles are doing. It is obvious, then, that such a tracing is an incomplete record of the heart mechanism, since it does not record the auricular movements also. How may the auricular movements be recorded as well? This was the next problem which faced the clinician.

The recent invention of the polygraph (see photo.) has at last given us the means whereby these auricular movements may be studied with perfect ease.

Examine the diagram Fig. 9. The blood in the veins proceeds towards the heart. But when the auricle contracts this contraction causes a little wave to be sent up the veins for a short distance *against* the stream. It is obvious, therefore, that if an instrument could be placed over the vein which could record the little wave, that would give us the time at which the auricle contracted. To obtain this record two conditions are necessary—(1) The vein must be near the heart. (2) The vein must be accessible. There is one large vein which answers both these requirements, and that is the *jugular vein.*

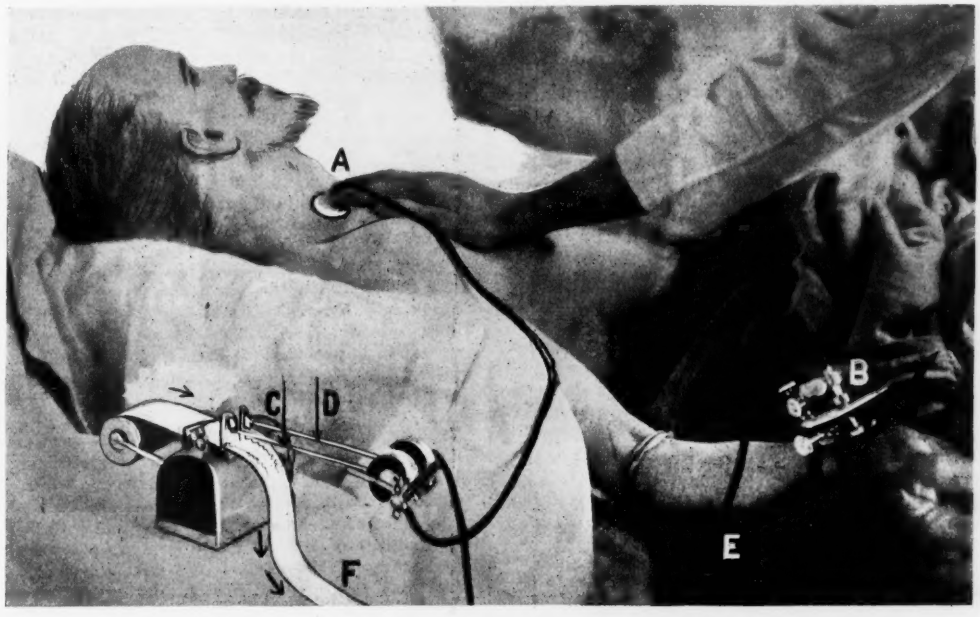


Fig. 10.—Photograph of Polygraph applied—Recording tracing.
A—Jugular Tambour. B—Radial Tambour. C—Needle recording Jugular Vein. D—Needle recording Pulse. E—Tubing (india-rubber). F—Paper Scroll.

The jugular vein, at the point where it passes under the collarbone (clavicle) from the neck to enter the chest, is only about six inches from the auricle itself. The jugular vein at this point is readily accessible for the tambour of the polygraph. It is the vein which is often visible to the naked eye, especially when the person has been exerting himself. It is this vein which is made use of by the clinician, and the little back-wave sent up it from the auricle can be readily recorded.

A tracing taken from this area looks like this:—

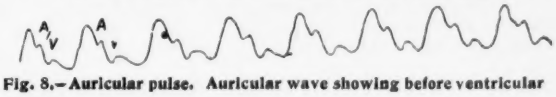


Fig. 8.—Auricular pulse. Auricular wave showing before ventricular

Here the first wave, A, is the wave sent along the vein by the auricle. The smaller wave, V, is the wave sent along from the ventricle into the carotid artery, which lies just beneath the jugular vein. It is seen here, then, that the auricular contraction begins before the ventricular, and the time between the two beats, A-V, is the time which intervenes between the auricular and ventricular beats. So, by this means, it is possible to record separately what all the four chambers of the heart are doing at any given moment. The importance of this knowledge will be the more obvious when it is stated that the auricular contraction acts as a stimulus, as a shock, to the ventricle to make it contract too.

Most stimuli to muscles in the body are conveyed along nerves. It would be expected, then, that a little nerve would be found in the heart which acts as a kind of telegraph wire between the auricle and the ventricle, along which the stimulus would pass from auricle to ventricle to cause the latter to contract. Such is the case, but with this difference, that instead of it being a nerve, it is a specialised sensitive portion of the heart muscle itself. It has only recently been discovered by physiologists. That is because it is so small that it has long evaded the most careful search. It is a little wisp of tissue not an inch long and only one-twelfth of an inch thick. It is situated in the very centre of the heart, as would be expected, between the auricles and the ventricles. It has been shown that the ventricle owes its stimulus to contract to the auricle. If this little telegraph wire between the two should be blocked in any way, then, the ventricles would get no stimulus and, therefore, they would not beat. That is to say, the heart would come to a standstill. The result would be instant death. This, no doubt, occasionally happens. On this delicate communicating wisp of tissue, called the *auriculo-ventricular bundle*, hangs existence itself. It is the golden thread of life. But Nature has mercifully arranged that it shall be so small and so sheltered in position in the heart that, as a matter of experience, it is rarely damaged even by extensive cardiac lesions. But sometimes it is slightly damaged, and then a curious thing happens. Only every other auricular contraction stimulus can pass through this bundle to the ventricle. Then we get a tracing like this :—

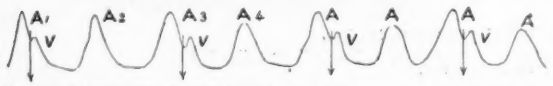


Fig. 9.—Only every alternate auricular beat causes a ventricular beat.

Here the ventricle, V, beats only once to every two beats of the auricle. The pulse in these cases is regular but very slow, often only 40 per minute. It is a dangerous state of affairs, though the patient himself may be unaware of anything abnormal. It means that this auriculo-ventricular bundle is damaged, and the slightest increase in this blocking of stimuli may cause the total cessation of all stimuli to the ventricle, and then death would be instantaneous.

With these methods of cardiac investigation it is possible nowadays to form a very accurate clinical picture of the heart mechanism in health and disease.

The day is at hand when a patient will not be content with a perfunctory examination at the hands of his doctor, to be told that he has, perhaps, a "weak heart," and to be presented with a bottle of "heart-tonic." He will expect a thorough instrumental examination, as by this means alone can the physician form any opinion of value on the cardiac condition of his patient and be able to treat him on correct scientific principles.

NOTES.

ASTRONOMY.

By CHARLES P. BUTLER, A.R.C.Sc. (Lond.), F.R.P.S., F.R.A.S.

VARIATIONS OF THE SUN'S DIAMETER.—Several observers have at times suspected variations of the sun's diameter, and have attempted to link the changes up with the known phenomena of solar activity which certainly exhibit periodical changes. Professor C. L. Poor has devised a very simple instrument for the detection of such changes, these being so minute that they are masked by errors of observation or definition when sought either from ordinary photographs or visual measures.

The new instrument, which he calls the Photoheliometer, consists of a double telescope, with object glasses 2 inches diameter and 25 feet focal length, rigidly mounted on the tube of the 40-inch Yerkes refractor. The distance between the optical centres of these lenses can be adjusted to any desired amount, and are usually fixed so that the two solar images overlap. It will be seen that if the length of the common chord to the two discs be measured accurately, any small variations of the diameters of the two discs will be more easily detected, because the length of the common chord is considerably altered by any small change in diameter. It is proposed to employ the instrument in determining whether the solar disc does vary in diameter from time to time.

FOCAL CHANGES OF NOVA PERSEI.—Professor E. E. Barnard has recently described some interesting measures of the changes in focus of Nova Persei, which, taken in conjunction with spectroscopic results from other observers, appear to furnish important data respecting the evolutionary development of the system. It will be remembered that Hartmann, at Potsdam, found that the spectrum of the new star changed to the nebular condition during the autumn of 1902. On again examining the object in 1906 he found that it then exhibited the spectrum of a Wolf Rayet star. Unfortunately, no intermediate observations were available to fix the epoch of the later change.

Barnard, working with the Yerkes refractor, recorded the peculiarities of the focus in comparison with that of ordinary stars, in 1901, 1902, and 1903. On October 1, 1902, the focus became suddenly nebular, being a quarter of an inch longer than that of a star. This condition lasted until November, 1902, when it slowly returned to the stellar stage by February, 1903. The last measures were made on September 28, 1903, when the focus was recorded as 0.03 *shorter* than that of a star. At first this result was suspected, but as it was subsequently found that the Wolf Rayet stars all exhibit the same peculiarity of a shorter focus than an ordinary star, the observation is considered as satisfactory, and the more so as this result fully confirms the conclusion of Hartmann, arrived at by spectroscopic investigation.

NEW FORM OF STELLAR PHOTOMETER.—Professor E. C. Pickering has recently described a new form of photometer for the determination of relative stellar magnitudes, and the resulting values will furnish important comparisons with those previously obtained by other methods. An artificial star is produced by passing the light from a small electric lamp through a minute aperture placed exactly at

the focus of an auxiliary telescope adjusted at right angles to the main telescope. By means of a reflector of plane glass at 45°, this light is then passed along the axis of the main telescope into the eye-piece. Opal or ground glass may be interposed between the electric lamp and the aperture, and the intensity may be varied by sliding along the axis of the small telescope by known amounts, so that the scale of the instrument will depend on the law of inverse squares instead of the phenomena of polarised light or the absorption of a glass wedge.

SOLAR PARALLAX.—Professor C. D. Perrine finds from the reductions of 281 photographs of the minor planet Eros, taken on 18 nights from October 6 to December 24, 1900 containing 823 images, that the value of the solar parallax is $8''.8054 \pm 0''.0025$.

VARIATION OF α HERCULIS.—This interesting star has for some time been regarded as an irregular variable, having a period of 30-40 days. Then Frost and Adams discovered evidence of its being a spectroscopic binary. F. Schlesinger discusses these results in conjunction with others at Allegheny, and suggests a period of about 2.05 days. From photometric measurements, Professor Wendell has later found evidence of the existence of a secondary minimum, and the two facts together thus strongly suggest that the star is a variable of the β Lyræ type.

STANDARD CLOCK RATES.—The accounts which continue to come in from various quarters regarding the rates of the new Riefler clocks give ample satisfaction for the confidence with which they have been installed. Professor W. S. Eichelberger, in his report on the standard clock Riefler 70, of the United States Naval Observatory at Washington, gives a detailed summary of the reductions of rate. Since the clock was installed in its vacuum case in a vault, maintained artificially at nearly uniform temperature, its performance has been so good that it has been found possible to devise formulæ from the daily observed rates with which he can predict the time corrections in advance to within 0.03 second. Tables are given showing the performance of the clock for stated periods.

BOTANY.

By G. MASSEE.

JUVENILE KELPS AND THE RECAPITULATION THEORY.—Professor R. F. Greggs records in the *American Naturalist* his views bearing on recapitulation as illustrated by a study of young kelps—species of the larger brown seaweeds. He observes that the recapitulation theory, or vestiges of racial descent during the development of an organism, was built up exclusively on zoological evidence, but botanists also approved it, and considered that it applied equally to plants, though not so obviously, as to animals. After general acceptance for some considerable time, the author is surprised to find the theory vigorously attacked by a section of zoologists, headed by Montgomery, and expounded in his "Analysis of Racial Descent," from which the following quotation is given: "The recapitulation hypothesis is scientifically untenable, and where there has been transmutation of species, the embryogeny neither in whole nor in part exactly parallels the racial history. The relation between them is always that of an inexact parallelism. Considerations based on any such idea of recapitulation are erroneous, and therefore of no help in determining racial descent." Hence the study of kelps in relation to the theory and the adverse criticism upon it.

Juvenile forms of all the kelps closely resemble each other in a general way, but it does not necessarily follow that this is due to recapitulation of phylogeny; it might be brought about by entirely different causes. After discussing the morphology presented by various genera, and taking all the evidence into consideration, the author feels bound to conclude, that though organisms are subject to adaptation at any stage of their life-cycles, and may gradually cut out superfluous stages, nevertheless, except as some such tendency has operated to change the heritage, the development of the individual does recapitulate the history of the race.

CEDAR OF LEBANON.—The general belief is that with the disappearance of the cedar forests of Lebanon, the cedar itself was practically lost as a wood of economic importance. This idea, however, is shown by a writer in the *Timber Trades Journal* to be an error, and that the cedar—*Cedrus Libani*, var. *Atlantica*, occurs in considerable abundance in certain outlying portions of Algeria, which have now been exploited and worked in a systematic manner. Many of these trees are magnificent specimens, very many centuries old, and yet sound and vigorous. The wood contains a peculiar resin, which gives a characteristic smell, which preserves the wood from the attacks of worms, moths, rodents, vermin, etc. For this reason, amongst others, the Greeks, Romans, Phœnicians, and Egyptians used to bury their illustrious dead in cedar-wood coffins. Some coffins containing the remains of celebrities of these remote periods, said to be made of this wood, may now be seen at the British Museum, in a wonderful state of preservation. The forestry portion of the Algerian Section at the Franco-British Exhibition was fitted with the Lebanon cedar, and contained many examples of the extreme durability of the wood. A specimen found amongst the charred remains of the old Roman city of Timgad, destroyed over 1,700 years ago, is in a marvellous state of preservation. According to Pliny, the beams of the Temple of Apollo at Utica were made of this wood, and were discovered in the same condition as on the day when they were used, after a lapse of 1,178 years.

This wood is now imported into our markets in large quantities, and promises to become once more, as much appreciated for its beauty and utility as in days of yore.

CAMPHOR IN CEYLON.—According to the *Pioneer*, the planting of the camphor tree (*Cinnamomum camphora*, F. Nees) is proceeding on a large scale in Ceylon. This is due to the high price of the drug, and the success attending the experimental work already done. In 1907, the acreage planted increased from 142 to 1,106 acres, and the area is still extending. The most favourable localities are situated at elevations ranging from 2,500 to 8,000 feet. It is believed that in a few years' time, Ceylon will be able to supply 8,000,000 pounds, about the quantity of camphor used annually at present. According to estimates it is believed that the cost per pound of camphor produced in Ceylon, due to the rapid growth of the trees, combined with cheapness of land of labour, will be much below the reputed cost of synthetic camphor made in the United States from turpentine.

CHEMISTRY.

By C. AINSWORTH MITCHELL, B.A. (Oxon), F.I.C.

MONTAN WAX.—A crude wax, resembling paraffin wax in its general chemical and physical properties, is obtained by extracting peat with petroleum spirit or benzene, and evaporating the extract. The crude residue is largely employed as an insulating material for electric wires. It may be purified by distillation with superheated steam, and is then suitable for the manufacture of candles, though as yet the purified product has not become commercially important. The recent investigations of Dr. Marcusson show that the wax consists, in the main, of bodies of high molecular weight in combination with alcohols of high melting point. It has a strong optical rotation, and the investigation of the nature of the constituents to which this is due may throw light upon the optically active constituents of petroleum, which, in the opinion of Messrs. Krämer and Spilker, is a derivative of montan wax.

STERILISATION OF WATER BY MEANS OF SILVER SALTS.—The addition of a small proportion of a silver salt

to water speedily destroys all micro-organisms, and after removal of the silver by means of chloride, the water is fit for drinking purposes. The current issue of the *Gazzetta Chimica Italiana* contains an exhaustive study by Dr. Traetta-Mosca, of the value of different silver salts in this respect. Sterilised water was inoculated with pure cultures of various bacteria including *B. coli*, and typhoid and diphtheritic bacilli, and definite quantities of this were added to sterile water containing the silver salt in the proportion of 1 in 10,000 to 1 in 500,000. In a typical experiment a cultivation made from water inoculated with *B. coli*, but not containing any silver salt, yielded 3,500 colonies per c.c., whereas from water containing 1 part of silver perchlorate per 10,000, no colonies were obtained, and that containing 1 part in 500,000 yielded 800 colonies after the silver salt had acted for 15 minutes, and only 10 colonies after 3 hours' action. Analogous results were obtained with the chlorate, sulphate, and fluoride of silver. The bactericidal action appears to be due, in the main, to the silver constituent of the salt, and even where the silver is apparently completely precipitated by chloride in the water, it is not improbable that some of the silver chloride remains in suspension in a colloidal form and effects the sterilisation. The acid radical in the salt, appears, to play some part, however, in the sterilising process, and Dr. Traetta-Mosca's experiments do not support the view of M. D'Anna, that it has only a negative importance in reducing the proportion of silver in the salt. Thus, silver chlorate, which contains 56.3 per cent. of silver, and silver perchlorate, with 52 per cent. of silver, have both a much more pronounced bacterical action, that silver sulphate, which contains 69.2 per cent. of silver.

A SIMPLE METHOD OF PREPARING HYDROGEN.—A cheap and convenient method of obtaining hydrogen is claimed by M. P. Maurichéau-Beaupré, in a recent French patent. Pure aluminium filings are mixed with 1 to 2 per cent. of mercuric chloride and 0.5 to 1 per cent. of potassium cyanide, and carefully protected from contact with moisture. When hydrogen is required all that is necessary is to add an equal weight of water. A reaction takes place in a few seconds and the temperature rises considerably. More water is then added in a constantly regulated quantity so that the temperature does not rise too high during the evolution of the gas. The process has the great advantage that both the materials used and the products of the reaction are non-corrosive.

EXAMINATION OF PALIMPSESTS.—Remarkable success has attended many of the attempts made to decipher the original writing on old parchments which had been scraped down and used again at a later period. In many cases the mechanical action of the pumice stone or other substance had been insufficient to remove completely characters possibly written three or four centuries earlier. Where the iron constituent of the ink had penetrated deeply into the vellum, it has been found possible to intensify it by the use of suitable reagents and thus to bring to light again valuable manuscript buried beneath the relatively worthless writing of a later time.

The best method of treating the parchment is to soften it by exposure to steam and the vapours of boiling acetic acid, and then to support it in a frame of threads in a closed glass box so that it is exposed to the vapours of ammonium sulphide contained in a small dish. The iron in the nearly obliterated writing is slowly converted into iron sulphide, and faint characters then appear deep black.

In some cases photography has been of assistance in deciphering the original writing on palimpsests, the pale yellow colour of the iron oxide of the old ink appearing black in a photographic copy.

The deciphering of modern writing which has been ruled or blotted out by a fresh layer of ink is a much more difficult task than the reading of palimpsests. Experiments made by the present writer show that in some cases it is possible, by the use of a very weak **bleaching** reagent, to remove the surface ink sufficiently to allow the lower pigment to be made clearer before it, too, is acted upon by the reagent.

GEOLOGY.

By EDWARD A. MARTIN, F.G.S.

THE BOVEY TRACEY FORMATION.—The Bovey Tracey Beds of clay and lignite which were correlated in 1863, by Heer and Pengelly with the Hempsted Beds, came to be classed as Lower Miocene, when the Hempsted Beds were placed there. Starkie Gardner thought that they corresponded with Middle Bagshots, or the Bournemouth leaf-beds, and classed them as Upper Eocene, and this view is now generally accepted.

Out of the seventy-two separate layers which were mapped out by Heer and Pengelly, only fifteen were found to contain fossils, viz., two of clay and thirteen of lignite. The fossils consisted of ferns (*Pecopteris lignitum* and *Lastraea stiriaca*), with twigs, leaves, and *débris* of *Sequoia couttsiae*. In the twenty-sixth bed from the top there was an abundance of seeds of various kinds, including those of the gardenia. In the fourth bed, Heer discovered a single specimen of *Buprestis falconeri*. In the 17-feet bed were found *Cinnamomum scheuchzeri* and *C. lanceolatum*.

The beds consist of sands, clays, and lignites, and are found in a plain stretching from north-west to south-east for a length of six miles, and having at its broadest part a width of four miles. The beds appear to have been laid down in a lake formed by an expansion of the two rivers. Bovey coal has been worked since 1714. The clay beds have been largely worked for pottery at Newton Abbot and Kingsteignton. Mr. J. Divett found that the lignite beds were cut off by a fault from the clay beds, giving a vertical displacement of not less than 100 feet, the lignite being probably the upper series.

THE BOVEY BASIN A TECTONIC BASIN.—On January 27 a paper by Mr. A. J. Jukes-Browne, F.G.S., was read before the Geological Society, on "The Depth and Succession of the Bovey Deposits." The total thickness of the tertiary beds in the Bovey Basin has never yet been ascertained, no boring having yet reached the bottom of the beds. A boring at Heathfield Potteries reached a depth of 526 feet from the surface, and, from particulars obtained by the author, he is able to give a generalised description of the beds. The Bovey Basin itself is regarded as a tectonic basin or post-Eocene pericline, and not as a lake-basin; although, during the deposition of the higher part of the series, it may have formed part of a large lacustrine or lagoon area, extending over the greater part of East Devon. Mr. Jukes-Browne dissents from Heer's view of the manner in which the lignites were formed, doubts the identification of some of the plants, and concludes that the lignites which form the mass of the lower beds represent the growth and decay of successive swamp-forests, similar to that of the Great Dismal Swamp of Virginia at the present day. Assuming that these lower beds are of Eocene age, and contemporaneous with the Bournemouth Beds of the Hampshire Basin, the author pointed out that nothing has yet been proved with regard to the higher beds, which may be of Bartonian, or even of Oligocene age.

CONWAY GEOLOGY.—Miss G. L. Elles, D.Sc., in a paper which was read before the Geological Society, on "The Conway Succession," records a complete succession in this area, from Llandeilian up to Salopian date. The sections examined show that there is no break whatever in the sequence between the Ordovician and the Silurian rocks in the district. Miss Elles gave in her paper a detailed comparison between the rocks of this area and those of South Wales, the Rhayader and Tarannon districts, the Lakes, the South of Scotland, and Pomeroy.

THE CHAPELLE-AUX-SAINTS SKELETON.—During the autumn of last year a discovery of intense interest was made by Messrs. J. and A. Bouyssonie and M. Bardon in excavating a cave in the commune of Chapelle-aux-Saints. The cave had evidently been filled in by the waters of a small tributary of the Dordogne River. The discovery consisted of a nearly complete human skeleton. The cranium was very much broken, and has been described by M. Marcellin Boule. The owner must have been short in stature, about 5 feet 2 inches.

The skull is dolichocephalous, with brow-ridges which are even more prominent than in the famous Neanderthal skull. Its general characters are extremely simian, and the lower jaw is remarkable for the absence of a chin. The man must have been of an extremely low type, and may be regarded as specifically different from living man. It was nearer to the anthropoid apes than to the human family. In considering the individual whose bones have thus been found, one must remember that it will always be possible to cast some doubt on the authenticity of this and similar specimens as representing at any time a normal type of man. Even the Neanderthal skull has been characterised in some quarters as a diseased or abnormal type of skull amongst those who were the owner's contemporaries. Human fossils are extraordinarily rare, but every fresh discovery of this kind will certainly tend to place even the few skulls which have been found of Pleistocene age in a surer position, as representing the normal type of a race having no recognisable living analogues.

"ITCHY-SILVER."—A correspondent in Lower Burma writes as follows:—"There is a substance to be found in certain parts of this country called by the Burmans Ngmayyah, literally, itchy-silver. The substance, which, according to the Burmans, is the purest silver, is found in large ingots. Immediately the substance is picked up the whole body itches to such an extent that it has to be put back. There is a way, I believe, of getting rid of this itchiness, but either the Burmans do not know or will not tell. Have you ever heard of such a substance, and, if so, can you tell me what it is? It could easily be got in large quantities if one only knew how to counteract the itchiness." Perhaps some of our readers can throw light on the subject.

SMITHSONIAN MISCELLANEOUS COLLECTIONS.—The following parts of Volume LIII. have been received:—Cambrian Geology and Palæontology, New Genera and Species of Cambrian Brachiopoda, and Classification and Terminology of the Cambrian Brachiopoda.

UNIVERSITY OF CALIFORNIA PUBLICATIONS.—The Department of Geology sends the following Bulletins:—Notes on Some California Minerals; Notes on a Collection of Fossil Mammals from Virgin Valley, Nevada; New Echinoids from the Tertiary of California.

METEOROLOGY.

By WILLIAM MARRIOTT, F.R.MET.SOC.

THE COLD SPELL IN DECEMBER.—This was referred to in last month's "KNOWLEDGE." Since then Mr. W. Marriott has discussed the observations made during that period, and communicated the results to the Royal Meteorological Society, in a paper on "The Cold Spell at the end of December, 1908." The weather during December was generally mild until Christmas Day, when a considerable change took place in the distribution of barometric pressure, and the weather assumed a wintry character. Gales occurred in many places and snow fell more or less over the British Isles during the following week. The most remarkable feature, however, was the intense cold which prevailed over the central and south-eastern portion of England from the 28th to the 31st. The temperature on the 28th did not rise above 25° over a considerable portion of the Midlands; while on the 29th it remained below 25° over practically the whole of England (except the south-western counties) up to within about 20 miles of the coast. On the 28th, 29th, and 30th, over the greater part of the country the minimum thermometer fell below 20°, while over a considerable area it fell below 10° on the 29th and 30th. At several places the lowest temperature recorded was about zero. At Berkhamsted, the thermograph showed that the temperature remained below 25° for a period of 58 hours—a most unusual occurrence. Mr. Marriott stated that the isobaric charts indicated that during this period there was a ridge, or wedge, of high pressure between two cyclonic systems, and that the conditions were thus favourable for the production of great cold. For the month of December the cold was very exceptional, as the only instances in the neighbourhood of London or at Greenwich in which the maximum temperature was below 25°.5 for the day were the following: 1796, 25th, 19°.5; 1798, 28th, 19°.5; 1816, 22nd, 24°.0; 1830, 24th, 22°.0; 1855, 21st, 23°.2; 1874, 31st, 24°.5; 1890, 22nd, 23°.7; and 1908, 29th, 25°.4, and 30th, 23°.3. Mr. Marriott said it was desirable that observers should have their minimum thermometers graduated down to −20°, and their dry and wet bulb thermometers graduated down to zero.

THE SNOWFALL OF DECEMBER 29, 1908.—A considerable amount of snow fell over the southern part of England on December 29. In some places the depth was about 7 inches. The snow was of a very dense character, and would not "bind," and was consequently difficult to walk upon. The traffic in London was seriously interfered with. Some interesting particulars as to the cost of the removal of the snow are given in the "Quarterly Journal" of the Royal Meteorological Society. It is stated that the weight of the snow which fell on December 29 on the 105½ miles of roads and streets in the borough of Hackney was estimated approximately at 20,000 tons. The cost of the extra labour employed in clearing the snow away amounted to £708 13s. 6d., extra cartage cost £250, and salt £121, making a total expenditure of approximately £1,080 consequent on the snowfall. In Holborn it was estimated that the total cost of snow removal in that borough amounted to about £1,400. The numbers of casual men employed, in addition to the Council's regular workmen, in the work of clearing the streets in connection with the snowfall, were—on December 29, 695; December 30, 656; December 31, 281; and January 1, 63. The total amount paid in wages was £525, but the total cost of the removal amounted approximately to about £1,400. The cost of clearing the snowfall in Lambeth amounted to the sum of £2,481 10s. 9d. The cost of removing the snow in the City of Westminster was nearly £5,000. At Greenwich the snowfall necessitated an expenditure of £679 18s. 10d.

Showing how large is the cost of snowfall to the community when spread over a large area, at Slough, twenty miles from London, £78 2s. 7d. was chargeable to the ratepayers (carting, £39 7s.; manual labour, £38 15s. 7d.), besides other sums paid by individuals for clearing roofs, etc. In the larger suburban towns, such as Croydon, Ealing, etc., still greater amounts have been spent on the removal of snow, without taking into account the expenditure of the provincial cities and of the railway companies.

GERMAN AEROLOGICAL EXPEDITION.—Dr. Richard Assmann, the Director of the Royal Prussian Aeronautical Observatory, Lindenberg, has given in the January issue of the "Quarterly Journal" of the Royal Meteorological Society, an interesting account of the German Aerological Expedition for the exploration of the upper air in tropical East Africa, during the months of July to December, 1908. The object of the expedition was to carry out kite and self-registering balloon ascents over the large Victoria Nyanza lake. In addition to the registering balloons, a large number of smaller pilot-balloons, carrying no apparatus, were sent up, often soaring to enormous heights, in order to complete the exploration of the wind. Their flight was observed with theodolites from fixed points on the shore. The most surprising result was the discovery of an uppermost current of air blowing nearly from due *west*, and flowing above the regular *easterly* current of the equatorial region. The lower strata, underlying the regular easterly trade, were swept by diurnal and seasonal winds, particularly by the sea and land breezes generally prevailing up to the height of 3,000 to 4,000 feet above the level of the lake.

PHENOLOGY AND WEATHER.—Mr. Edward Mawley, in his "Report on the Phenological Observations" for last year, points out that the most noteworthy features of the weather of the phenological year ending November, 1908, were the severe frosts early in January, the exceptionally heavy fall of snow and remarkably low temperatures in the latter part of April, and the marked periods of unusually wet and unusually dry weather during the summer. In February and March wild plants came into blos-

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som in advance of their usual time, but throughout the rest of the flowering season were more or less behind their average dates. Such early spring migrants as the swallow, cuckoo, and nightingale made their appearance very late. The only deficient farm crop was that of barley. The yield of wheat, oats, and beans was rather above the average, that of peas and hay very good, while the crops of turnips, mangolds, and potatoes, taken together, were the most abundant for many years. The yield of apples was under average, and that of pears and plums much under average. On the other hand, the crops of currants, gooseberries, and strawberries were almost everywhere unusually good. As regards the farm crops, this was the third good year in succession, although compared with 1906 and 1907, the yields in 1908, except in the case of turnips, mangolds and potatoes, were very inferior to those of either of those years.

ORNITHOLOGY.

By W. P. PYCRAFT, F.L.S., F.Z.S., M.B.O.U., &c.

THE FOOD OF BIRDS.—The study of economic ornithology in Great Britain is yet in its infancy, though had the Board of Agriculture done its duty we should long since have established a proper system of amassing information on this theme, fraught, as it is, with such significance both for the farmer, gardener, and naturalist.

As it is, the matter is left to private enterprise, and, as a consequence, "What is everybody's business is nobody's business."

However, there are some among us who do make observations on this subject. In *British Birds* for February Mr. H. W. Robinson has an interesting note on the food of the Red-breasted Merganser. In the specimen he dissected, *crabs*, and not fish, had recently formed its diet, and these crustacea, it may be remarked, are commonly eaten by cormorants, birds which are generally anathematized by fishermen on account of the enormous quantities of fish they are supposed to devour. Obviously this subject requires further study.

PALLAS'S SAND GROUSE IN HEREFORDSHIRE.—To the February issue of *British Birds* the Hon. Walter Rothschild contributes some interesting notes on rare birds lately seen at, or near, Tring.

The most striking of these is the record of a flock of seven or eight Pallas's Sand Grouse, which Mr. Rothschild himself saw at Tring on December 1, 1908. The birds were flushed out of a turnip field.

BITTERN IN HEREFORDSHIRE.—Mr. Rothschild also records, in the same communication, the occurrence of a Bittern (*Botaurus stellaris*) in Tring Reservoir, during the first few days of January, 1909. The bird stayed altogether about 10 days.

BITTERNS IN ESSEX, KENT, AND BRECONSHIRE.—In the *Field* (January 30), Mr. M. H. Wright states that a Bittern was shot, "during the last fortnight," by a boatman employed on Llangorse Lake, while Messrs. J. and W. Davis, in the *Field* (February 13), record the fact that they had received a bittern, with some wild-fowl, shot between Southend and Southminster during the last week in December, and on January 14 a fine adult male of this species shot in the Hawley Marshes, near Dartford.

EVERSMANN'S WARBLER IN FAIR ISLE.—The list of British birds is steadily growing. The latest addition is Eversmann's Warbler (*Phylloscopus borealis*), secured by Mr. W. Eagle Clarke at Fair Isle on September 28, 1908. This species, as Mr. Eagle Clarke points out in the Annals and Magazine of Natural History (1909), has only once before occurred in Western Europe, when, on October 6, 1854, a specimen was obtained in Heligoland. Passing the summer in Northern Europe, this little bird winters in Burma, Malaya, China, etc.

ICELAND FALCON IN SCOTLAND.—Mr. Fred Smalley, in *British Birds* for February, 1909, records the fact that on December 19, 1908, he received, in the flesh, a female Iceland Falcon, which had been killed some 10 days earlier on, or near, Callanish Light, Flannan Isles, by Stornoway, Lewis.

WHITE-TAILED EAGLE IN HEREFORD.—In *British Birds* (February) is a short note sent by Mr. H. E. Forrest, on a "four-year old White-tailed Eagle, shot near Hereford on December 31, 1908." The bird is ultimately to find a place in the Hereford Museum.

PHYSICS.

By PROFESSOR A. W. PORTER, B.Sc.

THE NATURE OF THE ALPHA-PARTICLE.—Professor Rutherford and T. Royds describe in the Philosophical Magazine for February an ingenious series of experiments intended to test whether or not an alpha-particle becomes helium when its positive charge is removed. In the usual way of demonstrating the production of helium as one of the products of the disintegration of radium emanation the helium is formed in the midst of the several other products, and hence it is left uncertain as to whether it is formed from the alpha-particle or is an independent product of the disintegration.

To resolve this problem the above investigators enclose the emanation in a very thin-walled capillary tube, which is, in turn, enclosed in an outer tube which is thoroughly evacuated. The alpha-particles which are shot out from the emanation penetrate the thin-walled enclosure in large quantities. The contents of the outer tube can at intervals be compressed into a very narrow capillary and an electric discharge passed. The light from the discharge is examined spectroscopically, and it is found that the spectrum lines of helium gradually appear. Blank experiments with helium contained in the inner tube show that helium itself is unable to pass through its thin walls. Hence it is concluded that the helium which appears outside has been formed from the alpha-particles themselves. Many modifications of the arrangement tend to confirm the conclusions of the authors. For a description of these we must refer to the original article. Short names seem to be required for the two sets of particles emitted by radio-active bodies; we venture to suggest the names, Alphones and Betones.

THE THEORY OF THE GREENHOUSE.—In the same Journal Professor R. W. Wood throws doubt upon the accepted theory as to the mode in which a greenhouse warms up under the action of the sun's rays. It is usually thought that the heating is due to glass being transparent to light but impervious to dark radiation. The luminous rays from the sun pass easily through the glass; being absorbed by the plants and soil they are transmuted into dark radiation which cannot escape through the glass; hence there is an accumulation of heat-energy inside. Professor Wood is inclined, on the other hand, to attribute the warming to heating by contact of the air with the ground warmed by the sun. Owing to this warming by contact, convection currents are set up which continually distribute the heat throughout the limited amount of air enclosed in the house, which, therefore, quickly rises in temperature. To test this explanation he arranges two boxes of blackened cardboard, one of which is covered with glass and the other with an equal thickness of rock salt. These are placed in the sun. Although the rock salt is almost equally transparent to dark and luminous radiation, the rock salt one shows an excess instead of the expected deficiency of temperature compared with the glass-covered one. If a piece of glass is put over the former so as to equalise the amounts of radiation which actually enter both, the two houses come to practically the same temperature.

It appears to us that this new explanation would explain much better the *rapid* heating of a greenhouse in the sun. According to the old theory, the warming would occur close to the glass roof and would, therefore, not be assisted by convection. The distribution would require to be effected, therefore, by conduction and radiation, and the combined action of these would be only small. Whereas, the explanation now put forward, supposes that the heat is given to the

air at its lowest levels, and, consequently, the very efficient convection currents are set up.

THE BOILING POINT OF RADIUM EMANATION.—The boiling point of the emanation has hitherto been thought to be −150° C. This value was determined by Rutherford and Soddy at a time when the quantity of available emanation was very small, and it, therefore, corresponded to a very low saturation pressure. Now that large quantities of emanation can be obtained, Rutherford has made new observations (which are recorded in a letter to *Nature* of February 18). It is found that the boiling point changes from −150° C. at very low pressures to about −65° C. at atmospheric pressure; that is, about 208° absolute. It is now possible to make a valid comparison with the boiling points (under atmospheric pressure) of the other members of the argon group. The values for argon, krypton, xenon, and emanation form practically an arithmetic progression. This is of special interest in connection with attempts made to determine the position of the emanation in the periodic table. It is consistent with the atomic weight 222 which has been assigned to it on the basis of other evidence.

Remembering that for the three former gases the critical temperature (absolute) is close to 1.75 times their boiling points, we may add that we expect the critical temperature of the emanation to be about 364 absolute; that is, about 91° C.; the critical pressure may also be somewhat higher than 43,500 mm. of mercury; that is, about 60 atmospheres.

ZOOLOGY.

By R. LYDEKKER.

ORIGIN OF THE AMPHIBIA.—Some very interesting observations have recently been published by Dr. R. I. Moodie, of Kansas University, with regard to the origin of the modern tailed amphibians, that is to say, salamanders and newts, which are well worth the notice of all naturalists. These tailed, or caudate, amphibians are known to date back in time as far as the Wealden epoch, below which no representatives of the group appear to have been hitherto discovered, although it has been stated that a member of the tailless group (frogs and toads) dates from the Jurassic. There occurs, however, in the Permian strata a group of salamander-like creatures of small size collectively known as the Branchiosauria, which, although generally classed with the Labyrinthodonts in the larger group known as Stegocephalia, appear to have strong claims to be regarded as the forefathers of our newts and salamanders. They have, indeed, been considered to be more akin to another group of small Permian creatures known as the Microsauria; but they differ from these and all other members of the so-called Stegocephalia in having short, heavy, straight ribs, like those of modern amphibians, the ribs of the Microsauria being long, thin, and curved. The Branchiosauria, of which the genera *Branchiosaurus* (or *Protriton*) and *Melanerpeton* are typical representatives, likewise resemble modern amphibians in having only four front toes, the numbers of the joints in which also correspond with those of the modern group. It is true, indeed, that one palæontologist has restored a branchiosaurian with four front toes, but this appears to be incorrect.

To make a long story short, it may be stated that, in addition to the characters of the ribs and fore feet, the Branchiosauria agree with the caudate amphibians in the structure of the skull and vertebræ, the characters of the pectoral and pelvic girdles (the former of which is degenerate in both), the character of the lateral line system, the structure and form of the long bones of the limbs, and, finally, in the shape of the body. What more is required in order to indicate genetic affinity between any two groups is difficult to imagine.

Dr. Moodie is, accordingly, of opinion that the caudate amphibians of the present day and their immediate ancestors are but degenerate branchiosaurians (the degeneracy of the former group being very generally admitted), and that the changes which have taken place in the skeleton have been mostly brought about by the loss of certain elements. As to the origin of frogs and toads, Dr. Moodie promises a further communication, which will be awaited with interest.

If these conclusions be well founded, it follows that salamanders and newts have one of the longest pedigrees in the whole animal kingdom. One gap in our knowledge—and that a most important one—remains to be filled, namely, the interval between the epoch of the branchiosaurians and that of the modern amphibians. That the connecting links between the two groups did not exist in Europe would be a very remarkable fact; but certainly none are known, and it is possible that they lived in some totally different part of the world. Had they occurred in Europe during the Jurassic epoch, their remains ought certainly to have been preserved in the fine lithographic limestones of the Continent, which have yielded Archæopteryx.

One other point remains to be noticed. If the Branchiosauria are true amphibians, it becomes manifest that the other Stegocephalia are not; and as the latter show many affinities with the true reptiles, it has been suggested that they should be affiliated to that class. They cannot, however, all be classed under any single head, since they represent divergent branches, and the logical conclusion is, therefore, to split them up and arrange them with the various reptilian groups to which they severally appear to be ancestral.

PAPERS READ.—At the meeting of the Zoological Society held on February 2, Dr. C. W. Andrews gave a lantern demonstration of the results of his recent trip to Christmas Island, in the Indian Ocean. On the same occasion, Dr. H. G. Palmer submitted a report on pathological observations undertaken in the Society's menagerie during the past year; Mr. H. S. Leigh contributed a preliminary account of the life-history of one of the leaf-insects; and a paper by Mr. E. C. Chubb, on the mammals of Matabililand, was read.

REVIEWS OF BOOKS.

ASTRONOMY.

Perth Catalogue of Standard Stars Between 31° and 41° South, for 1905.—Mr. W. E. Cooke, the Government Astronomer for Western Australia, is greatly impressed with the value of co-operation in meridian work as well as in other branches of astronomy. His idea is that each co-operating observatory should produce from its own observations, catalogues of standard stars, at fixed intervals, always including the same stars. This scheme would appeal to those who have the labour of preparing a fresh working catalogue for each successive period, as is done at Greenwich, for instance, but we must confess that some of the advantages are rather illusory. If there were no overlapping of catalogues they could not well be compared. If one co-operating observatory fell short of the standard of efficiency, their particular list of stars would suffer out of all proportion. Again, there is not necessarily any guarantee that the inevitable changes in (say) ten years at any one observatory, would not go far to nullify the expected homogeneity of its successive catalogues. However, the work before us includes standard stars of a zone overlapping at both ends that assigned to Perth Observatory in connection with the astrographic chart, and the present intention is to repeat this catalogue every ten or twelve years, aiming to include at least ten observations of each star in each successive catalogue. The necessity for the present catalogue arose from the insufficient number of stars in the zone required in Auwers' Fundamental Catalogue for Southern Zone Observations. In order to increase the number to practically three for every square degree of the zone, or ten to twelve for every plate of four square degrees, the stars of the present catalogue have been selected as secondary standards, and a year devoted to obtaining satisfactory places of all of them. They will then be used for reducing the observations of the larger catalogue for the Perth zone of the astrographic catalogue. The present catalogue contains some 425 stars, of which less than 100 are "fundamental," and in addition nearly 100 close companion stars are given, so that the list of stars, if well

observed every ten years, will not fail to provide much material for interesting investigation. The work is not overburdened with analytical details. No names are given, nor reference numbers to other catalogues, merely the reference number, magnitude, mean date, and number of observations in each element, and the mean place, precession, secular variation, and proper motion for 1905-6; the only other column, headed "remarks," being confined to notes as to other stars near, to assist in identification in a few cases. If Mr. Cooke's system is extended elsewhere and conscientiously and efficiently carried out, the value of the result would soon be very great, and would rapidly increase with each successive issue.

The Judgment of Paris, and Some Other Legends Astronomically Considered, by the Hon. Emmeline M. Plunket (London: Murray, 1908; pp. iii. and 199, illustrated; 7s. 6d. net).—In this elegant little volume the author, who is already well-known to the reading public in connection with ancient calendars and other archæological subjects, seeks a definite origin for the legend of the three goddesses—Hera, Athene, and Aphrodite—who submitted themselves to the judgment of Paris. Starting from the fact that archæology has proved the immense antiquity of the arts and astronomical science in Egypt and Babylonia, Miss Plunket has elsewhere suggested that the ancient Accadians had formulated a calendar to accord with the zodiacal signs, and that in order to keep themselves true to a fixed point on the ecliptic they inserted in this luno-solar calendar an additional month either in the middle or at the end of their years. As to the date of this calendar, the author boldly fixes it at the remote epoch of 6000 B.C.; and this, for the reason that, owing to the precession of the equinoxes, the sun then entered the first point of Aries at the winter solstice instead of at the vernal equinox. Arguing from this assumption as a basis, Miss Plunket then proceeds to show that Athene must be the cold mid-winter full moon (which would accord well with the petrifying stare of the Gorgon's head). Aphrodite, on the other hand, will typify the genial summer moon, while Hera will be the new moon; Paris himself personifying the spring equinox. Whether or no we admit the author to have proved her argument, all readers should be charmed with the brilliant and fascinating style in which she has put her thoughts on paper.

BIOLOGY.

The Science and Philosophy of the Organism; the Gifford Lectures delivered before the University of Aberdeen in the year 1908. By Hans Driesch (London: A. and C. Black, 1908; pp. xvi. and 381; 10s. 6d. net).—With this second volume Dr. Driesch completes his elaborate and thoughtful work, which is one for the earnest student, from whom it will demand no small amount of brain-power if its contents are to be properly assimilated. The discussion commenced in the first volume, in which the subject is regarded from the point of view of "science," is first thought to a conclusion, while the remainder and larger portion of the volume is devoted to the "philosophy" of the organism. It is, however, pointed out that the work is not one on general philosophy, the problems of which—and even those of the general philosophy of Nature—receive but brief attention. The general standpoint of the work is subjective-idealistic; but idealism is treated merely as a method, and subjective idealism is no longer regarded by the author as final, although there does exist the possibility of a certain knowledge about absolute reality. It is refreshing to find that the author is a believer in some form of teleology. "Certainly," he writes, "the primary 'entelechy' that natural science allows us to assume hypothetically, and epistemology allows us to refer by analogy to absoluteness, remains far behind any conception of a perfect absolute Being that man is able to form in his mind. But it does not contradict the concept of God as formed by the reasoning imagination." To all seekers after abstract truth, who are not frightened by hard words and still harder sentences, the work may be heartily commended.

The Problem of Age, Growth, and Death: a Study of Cytomorphosis (Progressive Science Series), by C. S. Minot (London: Murray, 1908; pp. xxii. and 282, illustrated; price 6s. net).—As we all grow old, we ought all to be interested in this admirable volume, which is based on a series of lectures delivered by the author at the Lowell Institute in 1907. Senescence, or senile decadence, is exclusively an attribute of living matter, and is thus an essential feature of life, to end inevitably in death. Contrary to popular opinion, the author finds it due to development and growth, only growth in a wrong direction. Thus, the ossification of the costal cartilages which so commonly takes place in old age is but a continuation of the same process which produces bone in the ribs; but it is not for the good of the organism. Another novel point is that senile degeneration takes place much less rapidly in old age than in earlier years; our degeneration commencing in some form or another about the age of forty. Whether it will ever be possible to delay the appearance and advance of senescence, the author leaves an open question. If, however, it be true that growing old (which is clearly a form of cell-growth) depends upon the increase of protoplasm, or cell-matter, and the proportionate diminution of the cell-nucleus, it may perchance be possible in the future to discover some means by which the activity of the nuclei can be stimulated, and the younger system of organisation thereby prolonged. But, for the present at any rate, we must be content to grow old in the old-fashioned manner. We heartily commend Professor Minot's volume to all our readers, scientific or otherwise.

BOTANY.

British Mosses, by the Right Hon. Sir Edward Fry, G.C.B. (London: Witherby and Co., 1908; 1s. 6d. net). A second edition of this excellent little book was inevitable as it stood alone in the method of treating the subject. In most previous works the subject was approached as if it constituted the plant kingdom at large, whereas here, in addition to specific details, the influence exercised by mosses in producing the present order of things on the earth is treated in an interesting manner, and excites far more general interest in the group than can be derived from a knowledge of plant names alone. The work has been thoroughly revised, and the illustrations, with one exception, re-drawn.

Trees: A Handbook of Forest Botany, etc., Vol. IV., Fruits, by the late H. Marshall Ward, D.Sc., F.R.S. (Cambridge University Press, 1908; 4s. 6d. net).—The present book is in every respect entitled to the unanimous verdict of excellent, bestowed on the three preceding volumes. The subject is treated in two parts. Part I. deals with the various structures resulting from pollination and fertilisation, which collectively constitute, in popular language, the fruit. The numerous excellent figures enable the student to follow the various complications which, in numerous instances, mask the fruit proper. Part II. treats of the classification of trees and shrubs according to their fruits and seeds. In this section the various forms of fruit and seed characteristic of the leading orders of plants are discussed, and the misleading nature of superficial resemblances indicated. The difficulty often experienced by a beginner in distinguishing between a fruit and a seed is also fully dealt with. Dr. Percy Groom, who is also an authority on trees, has edited the present volume, and announces in the preface that the late author left sufficient manuscript for a fifth, and final, volume, which is now in the press.

CHEMISTRY.

Recent Advances in Organic Chemistry, by A. W. Stewart, D.Sc. (London: Longmans; pp. xi. and 296; 7s. 6d. net). The justification for this book, if such were needed, may be summed up in the author's words, that while "we are all sufficiently glib in describing *how* a reaction takes place, very few of us seem to give a thought to the problem of *why* the reaction takes that particular course rather than another." The subject matter throughout is dealt with in a general way on these lines, and the temptation to overload the argument with a huge mass of detail has been resisted. As in his work on "Stereochemistry," Dr. Stewart has indicated new directions in which the student may attempt to find a path for himself through the fog of isolated facts with which he is often overwhelmed in works on organic chemistry. In short,

the book is constructive as well as instructive. After an introduction by Dr. Norman Collie, it opens with an extremely interesting survey of the trend of modern organic chemistry, and then deals with the synthetical formation of different classes of compounds, each stage in the synthesis being discussed in a separate section. Chapters are also given to the discussion of the influence of light on organic reaction, and of theories of unsaturation and the nature of addition reactions, and the work concludes with a bibliography and subject and name indexes. It will be found a thoroughly stimulating and suggestive book, even by the most advanced workers in chemistry.

Intracellular Enzymes, by H. M. Vernon, M.A., M.D. (London: Murray; pp. xi. and 240; 7s. 6d. net).—This volume affords yet another proof of the increasing interest that is being taken in the subject of enzymes—those remarkable substrata of specific forms of energy, which afford a common ground of investigation for the physiologist, chemist, and physicist. It consists of an expanded version of lectures given in the University of London, and deals, in the main, with the intracellular or endo-enzymes, those bound in some unknown way to the living cell, and not separable until after the death of that cell. The action of exo-enzymes, those which, like pepsin, are excreted from the living cell, are only dealt with in so far as is necessary to illustrate the general characteristics of enzymes. The book gains considerably in fullness of detail by this limitation of the subject matter. The nature of anti-ferments, bodies with a specific neutralising action for enzymes analogous to that of the anti-toxine for the toxine, is fully discussed, and full references to the most recent work in this and other branches of the subject are given. Throughout the explanations and reasoning are clear and sufficient, and the book must be regarded as a valuable addition to the library of the biologist.

NATURAL HISTORY.

The Transformations of the Animal Kingdom, by C. Depéret, translated from the French by F. Legge (London: Kegan Paul, Trench, Trubner and Co., Ltd., 1909; pp. xvi. and 360; 5s. net).—The publishers of the International Scientific Series have been well advised to issue in that valuable library a translation of "Les Transformations du Monde Animal." For in that work M. Depéret has discussed the problem of the evolution and dispersal of terrestrial vertebrates from the palæontological standpoint in a manner which has never previously been equalled, or, for that matter, attempted. No attempt will be made to review the book—which is one of the highest value and the greatest interest to all those to whom its subject appeals at all—in this place; and it will, therefore, suffice to state that after discussing the works of all the leaders who have contributed to the explanation of the doctrine of evolution, the author winds up by emphasising the predominant importance of migrations in explaining the absence of complete sequence between many of the European mammalian faunas. Short work is made of some of the pedigrees drawn up by other palæontologists; the horned rhinoceroses, for instance, being regarded as immigrants from Africa or Asia, instead of the descendants of the local hornless species. The author is also of opinion that too little time has been assigned to the evolution of the horse; but it does not seem to be shorter than that in which we know the origin of the elephant to have taken place. Unfortunately, the translation is marred by the fact that the editor appears unacquainted alike with technical terms and with the classics. To take only a few blunders, we find, for instance, *Mantill* for *Mantell* (p. 17), *square* for *quadrate*, *procoracoid* for *precoracoid*, *ilion* for *ilium* (p. 88), *centre* for *centrum* (p. 98), *Œluropos* for *Æluropus* (p. 151), and *Clupra* for *Clupea* (p. 170). The climax is, however, reached in a footnote on p. 315, where the editor speaks of "fruit-eating Chiroptera like the squirrel." If the book reaches, as it deserves, a second edition, it may be hoped that these blemishes will be removed.

Final Natural History Essays, by Graham Renshaw (Manchester: Sherratt and Hughes, 1907; pp. v. and 225, illustrated; 6s. net).—With this well-illustrated volume, containing four-and-twenty articles, the author brings to a conclusion a series of dissertations on a number of species of rare or otherwise specially interesting mammals. In nearly all cases these species are treated from the historical as well as from the purely zoological standpoint; and since Mr. Renshaw always writes in a pleasant and attractive vein, the volume should interest a large number of readers, including big-game hunters. While commending the work as a whole, we cannot, however, refrain from referring to passages which betray a regrettable lack of technical knowledge on the part of the author. We are told, for instance (p. 149), that the bubal antelope may prove to be a sub-species of the West African hartebeest, whereas the statement should have been just reversed, the former having been named in 1766 and the latter in 1869. Again, in the account of the udad, or African wild sheep, there is no mention of the fact that its range includes the Sudan as far south as Khartum. The statement on page 76 that the aurochs, or ancient wild ox, was white, varied with dun and red, is absolutely incorrect; while in his account of the European bison the author omits to mention that its Caucasian representative has been sub-specifically separated from the typical Lithuanian animal, and when discussing the races of the African buffalo (p. 88) he entirely overlooks Dr. Matschie's work, which was published early in 1906. It seems, moreover, a waste of energy to record museum specimens of such comparatively common animals as the bison and the white and the Beatrix oryx. Despite the above-mentioned and certain other blemishes, Dr. Renshaw's volume contains a large amount of valuable information, and well deserves a place in the library of every sportsman and naturalist.

The Labyrinth of Animals, including Mammals, Birds, Reptiles, and Amphibians, by Albert A. Gray (London: J. and A. Churchill, 1907; Vol. I., pp. xx. and 198; 21s. net, and Vol. II., 1908, pp. xiii. and 252; 25s. net).—Dr. Gray may be said to have created a new science. As the result of a novel and ingenious method of preparation, whereby the bony matter is removed and the membranous tissue alone left, he has made it easy to study the structure of the internal ear of the four higher classes of vertebrate animals in a manner which was previously impossible. The investigation was commenced seven years ago; and in the present volume the author describes the labyrinth of a number of representative species selected from six of the mammalian orders; thus leaving the remaining mammals, together with birds, reptiles, and amphibians for the second. The illustrations are reproduced from photographs by the author, and are in duplicate, so as to admit of being viewed through stereoscopic lenses, a pair of which is furnished with this volume. The author hopes that his work may prove of value both to the physiologist and the aurist; the method of preparation of the structures described furnishing the latter with fresh means of investigating the pathological changes which ultimately result in deafness, giddiness, or tinnitus. It is also hoped that the detailed description of the labyrinths of a number of animals will be of use in systematic zoology. With the exception of the egg-laying group, the cochlea in all mammals possesses the well-known spiral form. There are, however, two distinct types of cochlea in this class, the flat and the sharp-pointed; the former occurring in cetaceans, man and monkeys, ungulates, sea-cows, bats, and insectivores, while the latter is found in carnivores and rodents. Such a grouping is, perhaps, a little surprising, as it does not altogether accord either with the classification now generally accepted or with the one based on the characters of the placenta. Still, it is notable that the primates (man and monkeys) and ungulates, which are probably allied groups, have the same type of cochlea; and it is specially interesting to find that sirenians (sea-cows) accord in this respect with ungulates. On the other hand, the fact that the cetacean is different from the carnivorous type is just, in the light of modern discoveries, what we should not expect. Whether or no it will ultimately lead to any modifications in our schemes of classification, the work is of the highest value and interest, and affords eloquent testimony to the industry and originality of its author. We are glad to see that the Carnegie Trust has assisted in

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the publication of the work. Much interest attaches to the author's account in the second volume of the membranous labyrinth of the porpoise, our only regret being that specimens of the same region in other cetaceans were not obtainable. After mentioning that the bone (periotic) in which the labyrinth is contained is movably attached to the skull in the porpoise, in common with other cetaceans, Dr. Gray states that the membranous labyrinth differs from that of any other mammal he describes by the remarkable disproportion between the spiral cochlea on the one hand, and the semicircular canals and vestibule on the other. It remains to ascertain whether this feature is an adaptation to an aquatic existence, and, if so, common to cetaceans generally. In all respects volume II. maintains the high character of its predecessor; greater commendation it is impossible to bestow.

Die Termiten oder Weissen Ameisen, by K. Escherich (Leipzig: W. Klinkhardt, 1908; pp. xii, and 198, illustrated; 6s.).—All insects living in colonies and carrying out the needs of the colony by means of specialised sexless workers have a more than ordinary interest, not only to the entomologist, but to the student of Nature generally. Among such social insects termites, commonly miscalled white ants, hold a very high position—a position which is regarded, indeed, by the author of the interesting little volume before us as the culminating point of social life among the inferior animals; while they have a further claim on the attention of all residents in India and Africa on account of their destructiveness to woodwork of all kinds and household articles generally. Professor Escherich, who has had the advantage of advice and assistance from Mrs. Kunze and Messrs. Wasmann and Ludwig, appears to have treated his subject in an exhaustive manner from almost all points of view, and his work will doubtless long remain the standard manual on white ants. The volume is illustrated, in addition to text-figures, with a coloured plate, representing the gigantic royal cell, surrounded by workers, and guarded by an outer ring of soldiers.

ORNITHOLOGY.

The Sportsman's British Bird Book, by R. Lydekker (London: Rowland Ward, Ltd., 1908; pp. xviii. and 620; 30s. net).—As is indicated by its name, this exquisitely illustrated volume is intended to appeal to the bird-lover and the amateur naturalist (of which the sportsman is frequently one of the best representatives) rather than to the professed ornithologist; and it may be confidently asserted that those who consult its pages will find a large amount of information which cannot be obtained from any other work of a similar nature. In fact, it is not too much to say that, for its one special purpose, it is the best British bird-book before the public; the descriptions of the various species being as short and simple as is compatible with the due identification of each, while a very large amount of information in regard to distribution and habits has been compressed into a very small compass. The order in which the various groups are arranged differs from that adopted in the older works on the same subject, in accordance with modern views of taxonomy. Thus the book opens with the game-birds, as being the most generalised group (with the exception of the ostriches) and closes with the perching-birds, which are the most highly specialised of all. In commenting on this arrangement, one reviewer suggests that the game-birds are placed first to accord with the title of the book, thereby merely displaying his own ignorance of modern zoology. The illustrations, which are all done by photography, are simply beyond praise, and ought alone to induce a large sale of the book. In the first edition of a work of this nature some mistakes are inevitable; the wonder is that they are so few. By the accidental omission of a figure, the weight of the grouse is given too low, and should be 4½ lbs. instead of from 2½ to 3 lbs., which are the weights of young birds. There also appears to be an error (due to a previous compiler) with regard to the blue-winged teal, the first British specimen of which seems to have been one taken in Dumfries-shire in 1858. One reviewer maintains that recently introduced species, such as golden and Reeves' pheasants, ought to have been included; but the author has done wise in rejecting them. The book should be in every bird-lover's library.

PHOTOGRAPHY.

Photographic Optics and Colour Photography, by George Lindsay Johnson, M.A., M.D., B.S., F.R.C.S., etc. (London: Ward and Co., 1909; pp. xii. and 304; 7s. 6d. net).—This is the first volume of the "Lindsay Johnson Series of Handbooks on Applied Optics," written by the author "to cover the ground of the Spectacle Makers Company's Examination on that subject." The author is himself the examiner, and if the coming volumes deal with their subjects as fully as the present one, and those for whom they are intended pass the examination provided for them, the "optician" of the future will be a very different kind of man from what we have become accustomed to. Rather more than half the volume deals with optics from the photographic standpoint, and according to the author, "with the absolute minimum of mathematics." We can quite believe that some students would wish that the minimum might be possible of further reduction, but while a little more detailed explanation might perhaps be added in some parts with advantage it cannot be suggested that the author has treated the subject as an "exercise in mathematics." Cameras might have been treated of a little more fundamentally, and optical lanterns rather more fully, but perhaps these are regarded as of secondary importance. The chapter on the action of light on the plate, exposure, development, etc., of the negative seems to us quite out of place. It does not give as much information as many a maker's sheet of instructions that he issues with his goods. The volume will form a useful addition to the library of every student of photography, but it is a pity that so good a work should be marred by signs of the haste with which it has evidently been prepared. It needs a table of errata.* But even this would not meet the case of expressions that, on second thought, no serious student would allow, such, for example, as that "distortion is of no importance in portraiture or landscape photography," or that "the series (of stops) begins at f/2 and ends at f/64." We believe that the so-called "uniform system" is not now the one advocated by the Royal Photographic Society, as stated, but that they have adopted the natural unit of aperture f/1, which is also the unit adopted by the International Congress. On the same opening we note a figure of a "reversing prism" which is incorrect. We shall hope shortly to see a revised issue.

The British Journal Photographic Almanac, 1909, edited by George E. Brown, F.I.C. (London: Henry Greenwood and Co.; pp. 1,336; 1s. net).—The forty-eighth annual issue of this well-known publication is almost, if not quite, as bulky as ever, but, thanks to the editor, it is year by year made increasingly easy to refer to it. In the present volume there appears for the first time a classified index to the articles advertised, and this with the really good index to the text portion and tables of the book are very valuable features. Perhaps next year the editor may be able to go a step further and put the title page and table of contents at the beginning of the book instead of at page 515, and allow the text portion to immediately follow it. Besides the "Epitome of Progress," which deserves its name, and numerous items of tabulated matter, the editor contributes an article on "Reflex Cameras."

PHYSICS.

Photography for Students of Physics and Chemistry, by Louis Deer, M.A. (New York: The Macmillan Co.; London: Macmillan and Co.; 6s. net).—This is the result of an elective series of experimental lectures at the Massachusetts Institute of Technology on the general principles and processes of photography to students who have studied physics and chemistry. The endeavour has been to take a middle ground between the exhaustive treatise and manuals intended for the mere tyro. The chapters on the lens and its properties, while very elementary, are very clearly done. One noteworthy feature consists in the diagrams reproduced from microphotographs of the grains

*We have since received a list of Errata which, however, is not complete.

of various types of plates, and of the action of various intensifiers and reducers. We think the author's aim has been very well carried out.

The Radioactive Substances, by W. Makowe (London: Kegan Paul and Co., 1908; 5s.).—In spite of the number of books dealing with radioactivity the present volume will constitute a very useful additional one, especially to those who find the previous ones either too abstruse for them or (what is much worse) too trivial. Mr. Makower has endeavoured successfully to write an account which shall be accurate and at the same time as simple as the subject permits. He is himself an experienced investigator in connection with his subject, and consequently possesses the practical acquaintance with details, without which any attempt to write an elementary outline of a subject must necessarily fail. He has not failed. We think that his little volume will be of wide use in introducing the subject both to the college student and also to the more general reader or amateur experimenter, who wishes to acquire a real, even though it must be with him, a restricted knowledge.

ZOOLOGY.

Economic Zoology; an Introductory Text-Book in Zoology, with Special Reference to its Applications in Agriculture, Commerce, and Medicine, by Herbert Osborn (New York: Macmillan Co.; London: Macmillan and Co., 1908; pp. xv. and 490, illustrated; 8s. 6d. net).—That there is abundant room for a thoroughly good and comprehensive work on the economic aspects of zoology does not admit of a moment's doubt; whether the volume before us fulfils these conditions is another question. In a work of this nature one of the difficulties confronting the author is how much space to devote to the biological and how much to the economical aspect of the subject; in our opinion, Mr. Osborn has given us too much zoology and too little economics. The volume is, in fact (as implied to some extent in its title), a zoological text-book with notices of the economic side of the subject inserted here and there. Groups which are of no economic importance, such as the Polyzoa and Brachiopoda, receive equal treatment with those whose economic aspects are of the first rank; while in the case of the echinoderms we find no mention of the use of the common sea-urchin and of *bêche-de-mer* as articles of diet. Then again, the notices of the economic products of many groups of animals are ludicrously inadequate (notably in the case of the fur-seals), while in a large number of instances they are so short as to be difficult to find. The author is at his best in the treatment of the economic aspects of parasitic worms and injurious insects, and at his worst in the case of mammals, where we could point out several inaccuracies. Nevertheless, the work contains a large amount of valuable information, and is worthy of praise as an honest (if not altogether successful) attempt to meet a manifest want.

The Book of Nature Study, edited by J. B. Farmer, Vol. II. (London: The Caxton Publishing Co.).—We are glad to welcome the second volume of this attractive work, which deals with a large number of subjects, including insects, spiders, worms, freshwater and marine aquaria and their occupants, and the various haunts of animals. A coloured dissected model of a freshwater mussel affords a ready means of grasping the leading features of molluscan anatomy; while four other coloured plates serve to increase the attractiveness of the volume. Two of these plates are admirable, while the third is passable, but the fourth, representing a scene in an English beechwood, is much too red, while the squirrel, forming the central figure, looks as though it was carved in wood, and badly carved at that. When, however, the low price of the book is recalled, it behoves us not to be too critical. The various authors have treated their respective subjects in readable and apparently accurate style, and the volume is worthy of high commendation.

MISCELLANEOUS.

The Drink Problem, in its Medico-Sociological Aspects, by fourteen medical authorities. Edited by T. N. Kelynack, M.D., M.R.C.P. (London: Methuen and Co., 1907; 7s. 6d. net.).—A nation which conveniently forgets, refuses to recognise, or fails to realise, its infirmities must be awakened to its responsibilties, or what follows? It becomes cursed, with advancing physical and mental degeneracy, insidious in its approach, and subtle in its workings, and is a nation doomed. Read, mark, learn, and inwardly digest this work, for it speaks in no halting or uncertain language the part that alcoholism plays on the national stage. We cannot hide the fact, for the signs of the times indicate the necessity for compulsory military training, yet we heed not the call. Are we lulled into a sense of false security, and unable to appreciate the writing on the wall, by a mental languor co-existent with, and the outcome of, national decadence? Study Dr. Kelynack's authoritative and masterly exposition of our alcoholic failings, for his pages come opportunely as a reminder of our duties individually and collectively. To recognise manfully the existence of a Drink Problem; to strenuously support and advocate all efforts made and all measures introduced to combat this evil is a duty which appeals to the larger patriotism. Alcohol, as is unerringly proved in the chapters before us, is slowly, yet surely, sapping the vitality of our manhood. We welcome, then, this work, for it bears the impress of expert knowledge in all branches of the Drink Problem; it should be placed in the hands of those responsible for the education of our youth, all ministers of religion, and members of our Legislature. The introductory and final chapters are written by the editor himself. Among others, there are articles of fascinating and absorbing interest on the Evolution of the Alcoholic, the Psychology of the Alcoholic, Alcoholism and Mental Disease, Alcohol and Public Health, the Criminology of Alcoholism, Alcohol and National Deterioration, and Alcohol in Relation to Women and Children. The chapter on Alcoholism in Relation to Women and Children we particularise, because we are of opinion that female intemperance is on the increase, and are cognisant of the far-reaching consequences which that entails. We must pause to think what this fact means to the nation. Dr. Archdall Reid says: "The embryo of a drunken mother is practically another drunken person." Go a step further; such an embryo may never reach maturity, so here we have a factor in the production of a lowered birth-rate. If maturity is reached and the child lives to adolescence, it probably ekes out an existence as a mental and physical degenerate, joins the ranks of the "born tired" and unemployed, succumbs to the vices and temptations that indolence and degeneracy foster, and eventually becomes an inmate of an institution set apart for paupers, criminals, or lunatics. An alcoholic mother is generally incapable of suckling her offspring, through deficiency of milk, but what is worse, she often transmits this incapacity to her children. We cannot imagine a problem beset with greater difficulties than this one; a solution which is all-embracing is not to be found, but Dr. Kelynack, in his chapter on the arrest of alcoholism, points out the paths along which we must tread if we decide to ameliorate and arrest the curse of drink.—S. G. M.

The Evolution of the Atmosphere as a Proof of Design and Purpose in the Creation, and of the Existence of a Personal God, by John Phin (New York: The Industrial Publication Co., 1908; 191 pp., 8vo.; $1.25 net).—The author in the preface points out that the great contest which is at present waged between Christian theists and materialistic atheists—a contest over the fundamental principles of all religion, since it relates to the affirmation or denial of the very existence of God—unquestionably turns upon the presence or absence of design in creation. Haeckel denies that there is any evidence of design, and attributes everything to what he calls "blind chance." The author of this volume has attempted to prove by a new, and, as he thinks, a stronger argument than any that has ever before been presented, that the earth was created as the result of intelligent design, and consequently by a self-conscious and intelligent designer. In this book he endeavours to show that the proof of design in certain adaptations and necessary conditions, exhibited in the inorganic world—in the atmosphere which is essential to all the higher forms of life—is absolute and stands unaffected by any theory of evolution.

XUM

MICROSCOPY

Conducted by F. SHILLINGTON SCALES, M.A., F.R.M.S.

The Preparation of Microscopical Objects.

(*Continued from page* 78.)

The stains next to be mentioned are typical *regressive* stains. They may be made up with either water or alcohol, but are generally used in considerable strength, and the sections must be always *over-stained*. The time required may vary from 10 minutes up to 24 hours. The subsequent extraction of the excess of stain, with its diffuse coloration, is by means of 95 per cent. or absolute alcohol, and it is as well to just dip the sections first in water before differentiating. The stain comes out very rapidly in alcohol at first in streams, and looks as if it would all come out, but if the section has been sufficiently stained the excess of colour which is coming out will be found to get less until in about half a minute to two minutes it has nearly ceased, when examination will show that the section has cleared up wonderfully, and that the staining of the selected elements is sharp and precise. A little alcohol in a watch-glass is quite enough to use. Sometimes it is advisable to make the alcohol slightly acid with a drop or two of dilute hydrochloric acid. The sections are subsequently cleared and mounted in Canada balsam, the best clearing agents being cedar oil or xylol. Clove oil extracts yet more colour, and is apt also to distort the tissues. Mr. Lee points out that the results depend largely upon the fixing agent that has been used.

The following regressive stains of the Coal-Tar Series are those most commonly used.

Safranin.—This is a most useful stain and gives excellent and permanent results. It is especially useful for rapidly growing and dividing tissues. It is important to purchase the stain from a reliable maker, such as Grübler (London agents, C. Baker and W. Watson and Sons). "Safranin O" is commonly used. Safranin is not easily soluble in water, and is best made up with anilin oil as follows:—

Safranin	1 gram.
Anilin Water	90 c.c.
Alcohol, 95 per cent.	10 c.c.

"Anilin water" is made up by adding about 5 c.c. of anilin oil to 100 c.c. of distilled water, shaking well, and filtering through a wet filter paper. The stain must be filtered immediately before use, but it keeps for an indefinite time if kept in the dark. The time required for staining may be as much as 24 hours. It stains nuclei a beautiful red, but requires differentiating with alcohol as described above.

Gentian Violet.—This is also a most useful *regressive* stain, which stains nuclei blue. A suitable formula is:—

Gentian Violet	1 gram.
Anilin Water	80 c.c.
Alcohol, 95 per cent.	20 c.c.

The anilin water is best made as above. The stain is a very precise one, and is useful with thin sections, but requires differentiation with alcohol as already described.

Gentian Violet is, however, more especially used for staining bacteria, and though I do not wish to give special methods of staining, it is of such general use for this purpose that I may, with advantage, describe this particular application, the more so as it is an excellent example of *selective* methods. The following is the method known everywhere as "Gram's method" for differentiating bacteria, and it requires, in addition to the above solution, the following:—

Iodine	1 gram.
Iodide of Potassium	2 grams.
Water	300 c.c.

The bacteria, fixed in the usual way by heat upon the cover-glass, are stained for about five minutes with Gentian Violet *in the cold*, or the watch-glass containing the stain can be heated until the steam rises, in which case a minute will suffice. The cover-glass is then washed in water and placed for half a minute to two minutes in the iodine solution. The film will rapidly turn black. It is then transferred to alcohol or methylated spirit, and agitated in this until the film loses colour and becomes a pale grey. The film is then washed in water, dried between filter paper and in air, and when quite dry, mounted in Canada balsam.

The advantage of this stain is that it selects certain bacteria which *retain* the stain, whilst others quite lose it, and thus it is of great service clinically in distinguishing definite pathological bacteria. Amongst those which *retain* the stain are the bacilli of tubercle, leprosy, diphtheria, tetanus, yellow fever, and anthrax, and the streptococcus, staphylococcus, micrococcus tetragenus, and diplococcus pneumoniæ. Amongst those which are *decolourised* are the bacteria of bubonic plague, Asiatic cholera, influenza, dysentery, glanders, typhoid, bacillus coli communis, diplococcus intracellularis, gonococcus, and micrococcus melitensis.

(*To be continued.*)

Royal Microscopical Society.

January 20.—Anniversary Meeting. The Rt. Hon. Lord Avebury, F.R.S., President, in the chair. A reflecting microscope, made by Amici, presented to the Society by Mr. S. R. Roget, was exhibited and described by Mr. Rousselet. It was made in the early part of the last century on the principle of the Newtonian reflecting telescope in an attempt to overcome the chromatic errors in the microscope, achromatic objectives at that time being unsatisfactory. Mr. Conrad Beck exhibited a binocular microscope for the examination of patients' eyes by oculists, which had a magnification of × 18, a working distance of 3 ins., and is used at a sufficient distance from the eyes to enable the surgeon to look down and select his instruments. Mr. F. W. Watson Baker exhibited a new form of portable microscope, folding into a case $7\frac{1}{4} \times 4\frac{1}{2} \times 3\frac{1}{2}$, but less complicated than most instruments of this type. He also exhibited a student's microscope, known as the "Standard," with a new foot and a new form of fine adjustment at the side. Mr. F. Plaskitt exhibited some high-power photo-micrographs of *Podura* scales, taken to show their transverse markings. A large number of slides of Foraminifera, dredged off the coast of Somaliland, and presented to the Society by Mr. Ernest Heath, were exhibited under microscopes at the meeting. The Report of the Council for 1908 was then read. Sir Edwin Ray Lankester, K.C.B., M.A., F.R.S., etc., was elected as President for the ensuing year, and other elections were made of officers and Council. The retiring President, Lord Avebury, then read his annual address, entitled "On Seeds, with Special Reference to British Plants."

Quekett Microscopical Club.

February 5.—Annual general meeting. The reports presented by the Committee and by the Treasurer were considered satisfactory. Mr. F. W. Watson Baker, F.R.M.S., of Messrs. Watson and Sons, Ltd., gave a demonstration on "The Making of a Microscope Objective." There were exhibited specimens of optical glass in the rough, and slit, cut, and trimmed ready for edging and shaping. Optical workers' lathes were shown at which rough grinding and the final figuring and polishing of a high-power "front" were carried out. There was a further exhibit of "proof-plates" and of a method for roughly determining the refractive index of a block of glass. In acknowledging a vote of thanks, Mr. Watson Baker mentioned that, while in 1880 an eminent firm of optical-glass makers only listed six varieties, a recent Schott catalogue gave particulars of 80, and of these 80 there are many variants, sometimes as many as 100 of one kind.

Dr. Duncan J. Reid, M.B., C.M., gave a lecture on "A Method of Estimating the Exposure Required in Photo-micrography with Axial Cone Illumination." With a given N.A. and magnification the exposure for a standard subject is found experimentally. From this it is easy to calculate exposures under other magnifications and N.A. It is, however, necessary to measure the N.A. immediately before making the exposure. This is done by multiplying half the measured diameter of the Ramsden disc of the ocular by the magnifying power of the ocular and dividing by the focal length of the objective. Example.—Objective 4 mm., ocular × 4, diameter of Ramsden circle 1 mm. = N.A. 0.50.

In the discussion which followed, the Hon. Secretary, Mr. W. B. Stokes, suggested a simplification of Dr. Reid's method, viz., camera extension squared, divided by diameter of Ramsden circle squared, multiplied by a constant to be found by experiment.

Notes and Queries.

Hæmatological Slides.—Mr. Chas. Baker has sent me for inspection a particularly interesting set of slides illustrating the pathology of human blood. These are all counter-stained, and in several cases have the actual differential blood-counts written on them, together with the hæmoglobin estimations where necessary. The slides sent me included Splenic anæmia, in the infant and in the adult, Spleno-medullary Leukæmia, Pernicious anæmia, Leucocytosis with secondary anæmia, Chlorosis, and blood from a Sarcoma. They were in all cases typical, the two slides of Spleno-medullary Leukæmia in particular being two of the most interesting and instructive examples I have seen. The prices vary from 2s. to 3s. 6d. I can strongly recommend these slides to those interested in the subject.

Genitalia of the British Noctuidæ.—Mr. F. N. Pierce, F.E.S., has sent me a prospectus of a new work on this subject, in which he states that he has for twenty years been engaged in preparing and studying these interesting organs, and is now on the point of publishing his investigations. The work is illustrated with outline drawings of practically every recognised British species (about 320), and is so arranged as to enable students to compare the various groups and species, and thus to obtain an idea as to how far these organs may help in classification. Full instructions for the examination of specimens are given in an exhaustive introduction, wherein he has had the help of the Rev. C. R. N. Burrows. He appeals for a large number of subscribers, to enable him to issue the work at the modest price of 5s. per copy, and adds, "The work is entirely new, nothing of its kind having ever been attempted with the British Noctuæ, and the exceeding beauty of the structures will come as a surprise to the many who only know Lepidoptera by their wing markings." Any of my readers who may be interested in the subject, or desire further information, should apply direct to Mr. F. N. Pierce, The Elms, Dingle, Liverpool.

The Choice of a Microscope.—Messrs. W. Watson and Sons have issued an excellent little booklet of 16 pages with this title, which will be of great service to all beginners and to many who are no longer tyros, and which they will willingly send free to any applicants. Though issued with special reference to their own instruments, it contains information applicable to most other makes, and will help any purchaser to obtain a microscope that will give him satisfaction for advanced as well as elementary work.

"*Sigma*" (*Sutton*).—As you give me no details of your methods it is not easy for me to say wherein they may be improved. The sections of cuticles which you send me are rather thick, and the stained ones are too diffusely stained. Otherwise there is no abnormal structure to be seen. In some of them the nuclei are very large and well-marked, but they should be stained selectively. The cuticles are best fresh and young. They may be boiled with equal parts of nitric acid and water, but the boiling must not continue longer than two or three minutes, often less, or the structure will be ruined, stomata, in particular, being easily destroyed. They must then be washed *well* in water, the cuticles picked out, and examined to see if the overlying tissues have been removed, which does not seem to have been thoroughly done in some of your specimens. The sections are then stained with any nuclear stain, by the regressive method. Some cuticles are too delicate for treatment with acid, and are best macerated by soaking in water for a few days to a week or two, or even more, after which they can be examined under a hand lens, and any adhering tissues removed with a fine brush. After staining, dehydrate with 95 per cent. alcohol, clear with oil of cajeput or bergamot, and mount in balsam. The clearing and dehydrating are of importance. Suitable nuclear stains and methods of using them will be found in my notes on "Preparation of Microscopic Objects," now appearing in these columns.

J. M. (*London*).—I am afraid the limited space at my disposal will not enable me to give you details of interesting microscopic objects for low powers, but there are several inexpensive books which would give you the information and assistance you want, such as Lewis Wright's "Popular Handbook to the Microscope," published by the Religious Tract Society, at 2s. 6d.; or Wood's "Common Objects of the Microscope," published by Routledge, at 1s., in paper covers, or 3s. 6d. in cloth, with the plates coloured; or Cooke's "One Thousand Objects for the Microscope," published by Warne, at 2s. 6d. Either of the last two would give you an almost inexhaustible field.

S. H. (*Horwich*).—I would refer you to the answer given above. You would have no difficulty in mounting pollen or fern-fructifications. You will need 3-inch by 1-inch glass slips, $\frac{5}{8}$ inch or $\frac{3}{4}$ inch circular cover-glasses, a turn-table, a bottle of old gold size, a small sable or camel-hair brush, and some gum. Clean the slides and cover-glasses, clip the former centrally on the turn-table, and with a not too full brush of gold size make a ring upon them. One ring would be enough for pollen, but several will be required for thick objects like fern-fructifications, or it might be better to fasten on thin rings or cardboard, vulcanite, etc., to get the requisite depth. If rings are made of gold size each ring must be allowed to dry first before another is applied. Then cover the glass floor of the cell with a very thin film of gum, and when nearly dry sprinkle the pollen on it. The fern-fructifications are merely gummed in place with a small drop of gum. The slides must now be covered to keep them from the dust, and allowed to dry thoroughly, or moisture will condense on the cover-glass when the cell is closed. When dry make a final ring of gold size, and when it has dried enough to be just "tacky," put on the cover-glass. Later, ring the whole with a last coat of gold size or Brunswick black.

[Communications and inquiries on Microscopical matters should be addressed to F. Shillington Scales, "Jersey," St. Barnabas Road, Cambridge. Correspondents are requested not to send specimens to be named.]

The Face of the Sky for March.

By W. SHACKLETON, F.R.A.S.

THE SUN.—On the 1st the Sun rises at 6.49 and sets at 5.37; on the 31st he rises at 5.42 and sets at 6.29. The Sun enters the sign of Aries at 6.13 a.m. on the 21st, when Spring commences. Sun-spots and faculæ have been fairly numerous of late, and small groups may usually be observed on the Sun's disc. The positions of the Sun's axis, centre of disc, and heliographic longitude are given below:—

Date.	Axis inclined from N. point.	Centre of Disc S. of Sun's Equator.	Heliographic Longitude of Centre of Disc.
Mar. 2 ..	21° 56′W	7° 14′	139° 32′
,, 12 ..	24° 4′W	7° 12′	7° 47′
,, 22 ..	25° 32′W	6° 56′	235° 57′
Apr. 1 ..	26° 19′W	6° 29′	104° 4′

The Zodiacal light should be looked for in the West, a few hours after sunset.

THE MOON:—

Date.	Phases.	H. M.
Mar. 7 ..	○ Full Moon	2 56 a.m.
,, 15 ..	◐ Last Quarter	3 42 a.m.
,, 21 ..	● New Moon	8 11 p.m.
,, 28 ..	◑ First Quarter	4 49 p.m.

OCCULTATIONS.—The following are the principal occultations visible from Greenwich before midnight:—

Date.	Star's Name.	Magnitude.	Disappearance.		Reappearance.	
			Mean Time.	Angle from N. point.	Mean Time.	Angle from N. point.
			p. m.		p. m.	
Mar. 1	ω Geminorum	5·3	8 57	36°	9 38	334°
,, 3	γ Cancri	4·8	5 32	57°	6 27	318°
,, 25	B.A.C. 1240	5·7	10 43	109°	11 27	230°

THE PLANETS.—Mercury (Mar. 1, R.A. $21^h\ 8^m$; Dec. S. 15° 34′. Mar. 31, R.A. $23^h\ 29^m$; Dec. S. 5° 57′) is a morning star in Aquarius, rising at 5.51 a.m. on the 1st and at 5.23 a.m. on the 31st. The planet is at greatest Westerly elongation of 27° 26′ from the Sun on the 9th, when he rises 50 minutes in advance of the Sun; the elongation is not favourable for easy observation.

Venus (Mar. 1, R.A. $21^h\ 53^m$; Dec. S. 14° 6′. Mar. 31, R.A. $0^h\ 13^m$; Dec. S. 0° 12′) is also a morning star in Aquarius, rising only a few minutes in advance of the Sun, thus the planet is inobservable.

Mars (Mar. 1, R.A. $18^h\ 16^m$; Dec. S. 23° 39′. Mar. 31, R.A. $19^h\ 43^m$; Dec. S. 22° 11′) is visible in the mornings, rising about 3.30 a.m. near the middle of the month. The planet is situated in Sagittarius, but is rather an inconspicuous object. He will, however, become more interesting a few months hence, as the opposition of September approaches. The apparent diameter of the planet is now 6″.

Jupiter (Mar. 1, R.A. $10^h\ 46^m$; Dec. N. 9° 18′. Mar. 31, R.A. $10^h\ 33^m$; Dec. N. 10° 36′) is a brilliant object in the evening sky looking South-East, and is in the very best position for observation. Near the middle of the month the planet is on the meridian at 11 p.m., but observations may commence as soon as it is dark, since he is above the horizon at sunset. The most noticeable features as seen in the telescope are the moons, the dark belts, and the polar flattening; this latter is shown by the equatorial diameter being 43″·7, and the polar diameter 2″·8 less. If sufficient magnifying power be used with a telescope of about 4 inches aperture, markings and also the "Great Red Spot" on the belts may be observed, from which the period of rotation may be deduced. This is only $9^h\ 55^m$, which in some measure explains the shape of the planet.

The following table gives the satellite phenomena, visible before midnight:—

Date.	Satellite.	Phenomenon.	P.M.'s H. M.	Date.	Satellite.	Phenomenon.	P.M.'s H. M.	Date.	Satellite.	Phenomenon.	P.M.'s H. M.
Mar.				Mar.				Mar.			
1	I.	Ec. R.	8 40	13	IV.	Sh. I.	7 40	22	I.	Oc. D.	11 35
3	II.	Oc. D.	7 50		IV.	Tr. E.	8 51	23	I.	Tr. I.	8 55
	II.	Ec. R.	10 48		IV.	Sh. E.	11 56		I.	Sh. I.	9 27
7	I.	Tr. I.	10 59	15	I.	Oc. D.	9 51		I.	Tr. E.	11 13
	I.	Sh. I.	11 10	16	I.	Tr. I.	7 10		I.	Sh. E.	11 46
8	I.	Oc. D.	8 7		I.	Sh. I.	7 33	24	I.	Ec. R.	8 52
	I.	Ec. R.	10 35		III.	Oc. D.	9 9	26	II.	Tr. I.	8 43
9	I.	Tr. E.	7 44		I.	Tr. E.	9 28		II.	Sh. I.	9 56
	I.	Sh. E.	7 57		I.	Sh. E.	9 52		II.	Tr. E.	11 34
	III.	Ec. R.	10 4	17	I.	Ec. R.	6 57	27	III.	Sh. E.	8 11
10	II.	Oc. D.	10 5	19	II.	Sh. I.	7 21	28	II.	Ec. R.	7 53
12	II.	Tr. E.	7 2		II.	Tr. E.	9 17	30	I.	Tr. I.	10 40
	II.	Sh. E.	7 37		II.	Sh. E.	10 12		I.	Sh. I.	11 22
								31	I.	Ec. R.	10 46

"Oc. D." denotes the disappearance of the Satellite behind the disc, and "Oc. R." its reappearance; "Tr. I." the ingress of a transit across the disc, and "Tr. E." its egress; "Sh. I." the ingress of a transit of the shadow across the disc, and "Sh. E." its egress; "Ec. D." denotes disappearance of Satellite by Eclipse, and "Ec. R." its reappearance.

Saturn (Mar. 1, R.A. $0^h\ 37^m$; Dec. N. 1° 31′. Mar. 31, R.A. $0^h\ 50^m$; Dec. N. 2° 58′) is only available for observation for about an hour each evening during the first fortnight of the month, as he sets at 8.14 p.m. on the 1st and at 7.28 on the 15th. The planet appears as a fairly bright star looking nearly due West as soon as it is dark. Observed in the telescope, the ring appears slightly open as we are looking on the Southern surface at an angle of 8°. The apparent diameter of the outer and major and minor axes of the ring are 37″ and 5″ respectively, whilst the diameter of the ball is 15″.

Uranus (Mar. 15, R.A. $19^h\ 28^m$; Dec. S. 22° 20′) is visible in the mornings, rising about 3.45 a.m. near the middle of the month.

Neptune (Mar. 15, R.A. $7^h\ 2^m$; Dec. N. 21° 56′) is situated in Gemini, nearly midway between the stars ζ and δ Geminorum. Near the middle of the month the planet is on the meridian about 7.30 p.m., and sets about 3.30 a.m. The planet is difficult to identify among the numerous small stars appearing in the same field of view, and as he is practically stationary this month, he cannot readily be detected by his relative motion, moreover, it requires a high power (about 300) and good definition to distinguish his disc.

METEOR SHOWERS:—

Date.	Radiant.		Near to	Characteristics.
	R.A.	Dec.		
	h. m.			
Mar. 1-4 ..	11 4	+ 4°	γ Leonis	Slow; bright.
,, 14 ..	16 40	+54°	u Draconis	Swift.
,, 24 ..	10 44	+58°	β Ursæ Maj.	Swift.

Minima of Algol occur on the 7th at 9.29 p.m., the 27th at 11.12 p.m.; and the 30th at 8.1 p.m. Its period is $2^d\ 20^h\ 49^m$, by which other minima may be deduced.

DOUBLE STARS.—γ Leonis, $X.^h\ 14^m$. N. 20° 22′, mags. 2, 4; separation, 3″·8. In steady air, the prime requisite for double star observations, this double may be well seen in a 3-in. telescope with an eyepiece magnifying about 30 to the inch of aperture, but on most nights one with a power of 40 is better. The brighter component is of a bright orange tint, whilst the fainter is more yellow.